Ontario

Leading MATH Success

Mathematical Literacy
Grades 7–12

The Report of the Expert Panel on
Student Success in Ontario

Ontario Education

2004

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From the Chairs of the Expert Panels on Student Success in Ontario: Mathematical Literacy, Grades 7–12

May 2004

Fellow Educator:

This handbook is one of the two documents prepared by our panels for use in English- and French-language schools across the province of Ontario. These documents represent the Final Reports of the Expert Panels on Student Success in Ontario: Mathematical Literacy, Grades 7–12. They describe a vision and make recommendations to help create a brighter future for Ontario adolescents who are currently at risk of leaving high school without the mathematics skills and understanding they need to reach their full potential in the twenty-first century.

Our Expert Panels have worked with the Ministry of Education to develop these reports. We acknowledge with deep appreciation the Ministry's support during our deliberations and in the preparation and publishing of these reports.

These reports emphasize instructional and assessment strategies that will benefit all students. For struggling students, the use of these strategies is more than desirable: it is necessary. We must apply the latest thinking and research to the way mathematics is taught and learned.

Providing improved educational opportunities, however, is only part of the picture. Attitudes also have to change. A re-culturing of Ontario schools and, indeed, of Ontario society itself is necessary to affirm the value of mathematical literacy for all and to make this vision a reality. The Expert Panels believe we must say to all struggling students: *We will not give up on you.*

Our combined effort in moving the Leading Math Success reports forward represents another key phase in making success a reality for all students.

We wish you well as you continue this important work.

Yours in education,

Marilyn Gouthro, Chair
Expert Panel (English)

Janine Griffore, Chair
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Une publication équivalente est disponible en français sous le titre suivant : *La numératie en tête, de la 7e à la 12e année : Rapport du Groupe d'experts pour la réussite des élèves.*

This publication is available on the Ministry of Education's website, at http://www.edu.gov.on.ca.

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About the Expert Panel

This report has been prepared by the English-language Expert Panel on Student Success in Ontario. The Ministry of Education established this Expert Panel to provide direction to Ontario school boards on mathematical literacy for at-risk students in Grades 7 to 12. Members participating in the preparation of this report on mathematical literacy include the following education and community leaders from across the province:

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1 INTRODUCTION

Mathematics is a fundamental human endeavour that empowers individuals to describe, analyse, and understand the world we live in. The Expert Panel on Student Success in Ontario: Mathematical Literacy, Grades 7–12, was formed to help create a brighter future for Ontario adolescents who are currently at risk of leaving high school without the mathematics skills and understanding they need to reach their full potential in the twenty-first century.

"All teachers can make a difference for at-risk students with an emphasis on the moral purpose of educating our students."

(Program Pathways for Students at Risk Work Group, 2003, p. 25)

The statistics are troubling. To cite just one indicator, in the 2002–2003 province-wide assessment of the Grade 9 applied program in mathematics, 28 per cent of students scored well below the provincial standard (Education Quality and Accountability Office [EQAO], 2003b). Unless immediate, sustained, and effective action is taken, a sizable portion of the student population will leave school unprepared for the challenges they will face as adults.

Too often, society has accepted the stereotype that mathematics is for the few, not the many. The reality is that mathematics is deeply embedded in the modern workplace and in everyday life. It is time to dispel the myth that mathematics is for some and to demand mathematics success for all.

We must truly embrace the fact that every adult and therefore every child can do mathematics. If we convey the conviction that mathematical literacy is for everyone, our confidence in students will build their self-confidence. Self-confidence is a key ingredient in learning and success in mathematics.

Why Mathematical Literacy Matters

Mathematical literacy involves more than executing procedures. It implies a knowledge base and the competence and confidence to apply this knowledge in the practical world. A mathematically literate person can estimate; interpret data; solve day-to-day problems; reason in numerical, graphical, and geometric situations; and communicate using mathematics.

As knowledge expands and the economy evolves, more people are working with technologies or working in settings where mathematics is a cornerstone. Problem solving, the processing of information, and communication are becoming routine job requirements. Outside the workplace, mathematics arises in everyday situation after situation. Mathematical literacy is necessary both at work and in daily life. It is one of the keys to coping with a changing society.

Mathematical literacy is as important as proficiency in reading and writing. Mathematics is so entwined with today's way of life that we cannot fully comprehend the information that surrounds us without a basic understanding of mathematical ideas. Confidence and competence in mathematics lead to productive participation in today's complex information society and open the door to opportunity.

The Purpose of This Report

This report aims to provoke discussion and debate and to change how we view students at risk of underachieving in mathematics – and how we as a society support their learning.

Not all of the factors that influence educational success fall within the school system. For example, research shows that the foundation for learning is laid well before Kindergarten, let alone high school. The care and stimulation of infants from birth to age three are critical in establishing a basis for learning over the life cycle (Willms, 2003).

While this Expert Panel is conscious of the wider social context in which the factors that influence learning are established, its mandate is to speak primarily to educators. The people who work every day in education are closest to students and in the best position to identify students at risk and intervene to ensure their prospects for success.

Among educators, the role of teachers[1] of mathematics is pivotal. Teachers must be helped to develop the necessary mathematical understanding and must be given the tools they need to foster mathematical literacy. Teachers in many other disciplines can also create opportunities to help students appreciate the part that mathematics plays in their lives. And whether a teacher is teaching mathematics content or not,

1. When referring to teachers of mathematics, this report includes specialist mathematics teachers, teachers who teach mathematics as well as other subjects, and special education/resource teachers.

he or she must be a supporter of mathematical literacy by conveying the belief that all students can and should do mathematics.

Students' success depends on school, board, and provincial government leadership. Beyond that, parents and the wider community, from business firms to volunteer groups, also have a part to play. Everyone shares the responsibility for guaranteeing that all students receive support on their journey towards mathematical literacy. Ultimately, success depends on the students themselves and their response to the learning experience offered them.

This report is intended to inform and change educational practice, propose effective strategies and resources, and help shift attitudes both in our schools and in society. The challenge is to systematically identify students at risk and intervene decisively to close learning gaps. It is imperative that we apply the latest thinking and research to the way mathematics is taught and learned. We may use the best strategies to benefit all students, but we must use them to support struggling students. And even though we may use the best instructional and assessment practices with those students, some of them will remain at risk and will need targeted instruction and support.

Everyone is capable of becoming mathematically literate. The path towards this social goal begins at home and in the classroom, supported by the family and the community. All students can learn mathematics – with enough support, resources, and time – and we must ensure that they do.

We must re-culture Ontario schools and indeed Ontario society itself if we are to affirm the value of mathematical literacy for all and make this vision a reality. The Expert Panel believes that we must say to all at-risk students: We will not give up on you.

Foundations for Action

Guiding Principles

In preparing this report, the Expert Panel has been guided by the following principles:

1. Mathematical literacy is fundamental. It enables students to make life choices and participate productively in society.
2. All students can learn and be confident in mathematics, given appropriate support and time.
3. All students have the right to quality supports in learning mathematics to enable them to reach their potential.
4. It is the responsibility of the Ministry of Education, school boards, parents, and society to provide the necessary supports.
5. Effective classroom instruction can have a strong, positive impact on student attitudes and learning in mathematics.

6. Effective mathematics instruction must address the needs of the adolescent learner.
7. Connections to mathematical literacy should be made where they occur naturally across the curriculum.
8. All teachers of mathematics must be competent in teaching this subject and confident in their ability to do so. They must be given appropriate collaborative professional learning and resources to achieve this competence and confidence.
9. Teachers of mathematics must have a strong content knowledge, good instructional skills, and sound pedagogy to teach mathematics effectively.
10. All teachers can and should support the development of mathematical literacy.
11. Collaborative professional learning communities are essential to increasing student success.
12. Effective district and school leadership is crucial to improving student learning.

Constructing the Groundwork

To base its advice and recommendations on a solid footing, the Expert Panel:

- assessed the current Ontario context;
- explored the meaning of mathematical literacy; and
- reviewed current research on adolescent learners and on mathematics teaching and learning.

An overview of this groundwork is presented in chapters 2–4 of this report.

Priorities for Action

Having studied the Ontario context, the meaning of mathematical literacy, and current research on mathematics pedagogy, the Expert Panel has established the following priorities and calls on educators to work on them. Educators should:

- adopt the best mathematics instructional and assessment strategies for *all* students, emphasizing approaches that especially benefit students at risk and delivering additional targeted support as needed;
- build and sustain professional learning communities committed to meeting the needs of all students;
- gather and use information more effectively to identify students at risk in mathematics, make plans to provide the support those students need, track progress, and adjust strategies as required;
- show leadership and take action at all levels of the education system – classroom, school, district, and province – to promote mathematical literacy for all;

- forge links with families and the larger community to support students at risk in mathematics;
- encourage innovation designed to overcome the barriers to success that at-risk student face.

Chapters 5–10 of the report explain why the panel has adopted these priorities and show how they can be implemented. In each priority area, the report offers detailed, practical advice to educators on achieving the goal of mathematical literacy for all. For each priority, the Expert Panel also makes recommendations to guide classroom practice, the use of resources, and the expenditure of funds to meet the needs of students at risk in mathematics.

"All students can learn mathematics, and they deserve the opportunity to do so.... However, recognizing the diversity among ... children, educators do not expect all students to learn the material in the same manner, using the same resources, and in the same time frame."

(Sutton & Krueger, 2002, p.1)

2 The Ontario Context

A Focus on Students at Risk

The work of this Expert Panel reflects an important priority in Ontario's education system: to mobilize resources to support students at risk. The roots of this report go back to the At-Risk Working Group, which submitted its final report – *A Successful Pathway for All Students* – to the Minister of Education in January 2003. One of the key proposals of the At-Risk Working Group was the formation of expert panels on students at risk to further investigate its recommendations on literacy and numeracy[1] and to facilitate immediate action. In response, the Ministry of Education created English- and French-language expert panels on literacy and numeracy. Also in response to the report, a Program Pathways Work Group was formed to provide advice on successful school–work transition programs, effective remediation programs, and grade-by-grade pathway models to help students reach their educational and career goals.

"Ontario's schools should offer an education program that promotes a high standard of achievement, that provides all students with the learning opportunities and support they need, and that is relevant to society's needs and expectations."

(Ontario Ministry of Education, 1999b, p. 6)

"Teachers are responsible for developing a range of instructional strategies based on sound learning theory. They need to address different student needs and bring enthusiasm and a variety of teaching approaches to the classroom. Good teachers know that they must persevere and make every reasonable attempt to help all students develop their interests and abilities to the fullest extent."

(Ontario Ministry of Education, 1997, p. 4)

1. Instead of *numeracy*, this report uses the term *mathematical literacy*. The term *numeracy* may imply a narrow view of what students need. Influenced by research on mathematical instruction and assessment, this Expert Panel has adopted the term *mathematical literacy*, which suggests a broader view of what all students need than just the capacity for quantitative thought and expression. The panel's vision of mathematical literacy is described in chapter 3.

Composition and Mandate of the Panel

The English-language Expert Panel on Student Success in Ontario is made up of educators and community leaders chosen for their knowledge and expertise in supporting the learning of mathematics by adolescents. This report on mathematical literacy fulfils the mandate of the panel by addressing the following recommendations of the At-Risk Working Group:

- the application of diagnostic assessment to identify and track students at risk regarding the acquisition of numeracy
- the application of interventions that are based on research and/or are potentially the basis of action research or teacher education
- the use of learning resources selected as most supportive of students and teachers
- ongoing teacher education, including structured conversations among teachers about teaching and assessment methodologies
- the identification of successful practices and of resources available to support teacher education, in alignment with the resources already developed by the Expert Panel on Early Math, whose report was released in spring 2003
- professional learning to build the confidence level of teachers of mathematics in Grades 6–8 to support at-risk students
- the selection of resources to support community and parental involvement in the area of numeracy

The panel has interpreted its mandate broadly and has developed advice and recommendations on what it sees as significant related issues.

Funding Commitment

The report of the Education Equality Task Force, released by Dr. Mordechai Rozanski in December 2002, called for an additional investment of $50 million annually to improve at-risk students' readiness to learn – a recommendation the government accepted. In March 2003 it was announced that $10 million from this commitment would be used to establish students-at-risk leaders – now known as Student Success Leaders – in all school boards. Student Success Leaders are working with Grade 7–12 teachers and administrators to support improved teaching methods, deliver learning resources, and encourage the sharing of effective practices in literacy and mathematical literacy. Beginning in September 2003, all school boards were required to submit Annual Action Plans for Student Success that are funded from the remaining $40 million allocation. The recommendations of the Expert Panels and the Program Pathways Work Group are expected to shape the expenditures in these action plans in the years ahead.

Who Is at Risk?

When this report discusses students at risk, it is referring to two related risks: the risk of not developing mathematical literacy in school, and the consequent risk of not earning the three mathematics credits required for graduation with an Ontario Secondary School Diploma. Without mathematical literacy and a diploma, students face significant barriers to further education, productive employment, and participation in society.

The At-Risk Working Group (2003) defined "students at risk" as:

- elementary students who are performing at level 1[2] or below grade expectations;
- secondary students who would have studied at the modified or basic level in the previous curriculum;
- secondary students who are performing significantly below level 3 (the provincial standard), earning marks in the 50s and low 60s, and who do not have the foundations to be successful in the current curriculum;
- students who are disengaged, with very poor attendance.

Data from the mathematics assessments conducted by the Education Quality and Accountability Office (EQAO) in 2002–2003 help quantify some of these criteria. In Grade 6, 8 per cent of students were at level 1 (EQAO, 2003a). In the Grade 9 applied program, 20 per cent of students achieved at level 1 and 8 per cent were below level 1 (EQAO, 2003b).

Credit accumulation is also a key indicator of at-risk status. Schools typically require students to take eight courses in each of Grades 9, 10, and 11. After three years of secondary school, students who have successfully completed all courses will have gained 24 or more credits. In the cohort of students who began high school in September 1999, 26.4 per cent of students had 20 or fewer credits after three years. As a result, they were very likely to drop out of school before graduation. Another 5.4 percent had lost 3 credits, almost all including mathematics, and were also at risk (King, 2004).

Students who are mathematically literate possess the mathematical knowledge and skill – and the confidence to apply them – necessary for work and personal success in the twenty-first century. It is clear that a substantial proportion of Ontario adolescents face the prospect of leaving secondary school without having developed mathematical literacy. This cannot be allowed to happen.

2. Level 1, while reflecting passable achievement, is well below the provincial standard (level 3).

Remedial and Special Education

Schools can deploy a range of options to help close literacy and mathematical literacy gaps for students at risk in Grades 7–12.

Some school boards use the term *remedial education* to describe the targeted support they offer to close gaps, and draw a clear distinction between this assistance and the formalized and regulated programs and supports involved in *special education*. Here is one way to understand these distinctions:

- *Special education** is intended for students who have been formally identified as exceptional because of their behavioural, communication, intellectual, physical, or multiple needs. These students need regular and ongoing modifications to the age-appropriate grade-level curriculum and/or accommodations to the learning environment. In practice, some school boards provide special education to students without formal identification. In both instances, the school board develops an Individual Education Plan (IEP) reflecting these regular and ongoing modifications and/or accommodations.
- *Remedial education* is generally viewed as a short-term intervention to raise the level of student achievement to an expected standard for the regular grade-level curriculum. This targeted support is often used to improve students' literacy and mathematical literacy skills, with the expectation that these skills will help the students to progress in all subject areas and eventually achieve the regular grade-level subject or course expectations. In these cases, regular and ongoing modification to the curriculum and/or accommodations to the learning environment are not necessary. Tutoring and study-skills workshops are two examples of this targeted support.

Some special education students are at risk regarding mathematical literacy, but others are not. Likewise, some students outside special education are at risk in mathematics, while others are not.

Experience has shown that learning strategies designed for special education students are often of value for students at risk, whether or not they are in special education. These include:

- strategies that can be used before, during, and after learning
- strategies that explicitly connect with the student's existing mathematical knowledge
- strategies that relate to the organization of information, and
- strategies that relate to the oral, reading, writing, and visual aspects of mathematical literacy

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* Subsection 1(1) of the Education Act defines an "exceptional pupil" as:
a pupil whose behavioural, communicational, intellectual, physical or multiple exceptionalities are such that he or she is considered to need placement in a special education program by a committee [Identification, Placement and Review Committee]....

A "special education program" is defined in s. 1(1) as:
in respect of an exceptional pupil, an educational program that is based on and modified by the results of continuous assessment and evaluation and that includes a plan containing specific objectives and an outline of educational services that meets the needs of the exceptional pupil.

Regulation 181/98 requires that an Individual Education Plan be developed for every student identified as exceptional by an Identification, Placement and Review Committee. In addition, a school board may develop an IEP for students who have not been identified as exceptional but require special education programs or services.

Initiatives to Improve Mathematics Teaching and Learning

In this report, the work of the Expert Panel complements current initiatives in Ontario's education system to improve the teaching of mathematics and strengthen the learning continuum from Kindergarten through Grade 12. This report provides direction for helping students at risk become mathematically literate by making explicit the strategies that are recommended for all students and that particularly support struggling students.

Numeracy Strategy

The provincial government is implementing a numeracy strategy designed to help all primary and junior students build a solid foundation for future learning and begin to develop the mathematical skills they will need as adults. The objective is to improve the mathematics skills of Junior Kindergarten to Grade 6 students as measured by province-wide testing conducted by the EQAO.

The numeracy strategy includes specialized teacher training, teaching guides, web-based learning modules, in-classroom student learning resources, support for schools that need extra help, and a guide for parents on supporting their children's mathematics learning. As part of the strategy, the Expert Panel on Early Math in Ontario prepared a report (2003) outlining the elements of an effective program in mathematics in the primary grades and providing advice on the best assessment techniques for evaluating students' mathematics skills. The report anchors mathematics instruction in a problem-solving approach to student learning, with a focus on the "big ideas" or key concepts of mathematics. It establishes guidelines for developing and maintaining teacher expertise and makes recommendations for the classroom, school, and district levels.

Mathematics TIPS

In fall 2003, the ministry launched *Targeted Implementation and Planning Supports: Grades 7, 8, and 9 Applied Mathematics* (TIPS) (Consortium of Ontario School Boards, 2003). This resource, which is more than 600 pages long, was produced by teachers and school boards working in partnership, with the support of ministry funding. It contains program-planning supports, including five content-based packages, as well as day-to-day lesson and assessment plans, student worksheets, and electronic files for computer-based studies.

Based on a synthesis of current research, TIPS offers new ways of thinking about mathematics learning, resources, and teacher education. The goal is to help both teachers and students develop the "big picture" of mathematics, which includes competence in mathematical skills, the understanding of mathematical concepts, and the application of these skills and concepts in problem-solving situations.

The Expert Panel endorses TIPS and calls on all teachers of mathematics to use this invaluable resource. Chapter 5 of this report highlights TIPS strategies that are especially relevant to closing gaps for students at risk.

Other Classroom Support

The ministry has sponsored the preparation of course profiles for each secondary school course in the mathematics curriculum. The profiles suggest a presentation order, rich learning tasks, and assessment techniques. In cooperation with school boards, the ministry has also developed samples or *exemplars* of student work at the elementary and secondary levels. In addition, the ministry has licensed software to support students and teachers in schools across the province.

The ministry provides special funding for after-school mathematics programs for students in Grades 7–12. The goal is to build mathematical literacy skills for students who may have been struggling for years and need further assistance to overcome barriers to success.

Provincial Education Policy

Mathematics Curriculum Under Review

All students in publicly funded English- and French-language elementary and secondary schools in Ontario are now studying the provincial curriculum that was released for Grades 1–8 in 1997 and phased in for Grades 9–12 starting in September 1999. The expectations outlined in the curriculum policy documents describe the knowledge and skills that students are expected to acquire by the end of each grade. In high school, students can choose between academic and applied courses in Grades 9 and 10 and among university, university/college, college, and workplace preparation courses in Grades 11 and 12. At the secondary school level, school boards may develop optional credit courses and certain compulsory credit courses where the provincial curriculum does not meet students' educational needs. These courses must be approved by the Ministry of Education. Many boards offer locally developed compulsory credit courses in mathematics.

Since September 1997, all mathematics programs for Grades 1–8 have been based on the current curriculum. The present secondary school mathematics curriculum was introduced over the course of four years, beginning with Grade 9 in September 1999 and concluding with Grade 12 in September 2002.

To obtain the Ontario Secondary School Diploma, students must complete 30 credits: 18 compulsory and 12 optional. Of the compulsory credits, 3 are in mathematics, and at least 1 of those credits must be at the Grade 11 or 12 level. Locally developed compulsory credit mathematics courses in Grades 9 and 10 may – as their title suggests – be counted as compulsory credits.

The elementary and secondary curriculum is reviewed on an ongoing basis to ensure that it remains relevant and continues to prepare Ontario students for future success. The Ministry of Education has established a five-year cycle for review of curriculum policy documents. Teachers, principals, board staff, content experts, parents, and students will have an opportunity to participate in this Sustaining Quality Curriculum process. Revisions will be made to the curriculum if the evidence demonstrates the need for change. Mathematics is included in year one of the review cycle that began in September 2003.

Assessment and Evaluation

The primary purpose of assessment and evaluation is to improve student learning. Assessment is the process of gathering information that accurately shows how well a student is achieving the curriculum expectations. Information comes from a variety of sources, including assignments, demonstrations, projects, performance tasks, and tests. Evaluation is the process of judging the quality of student work on the basis of established criteria and assigning a value to this quality. Assessment and evaluation are based on the achievement charts provided in the provincial curriculum policy documents.

The achievement charts are organized into four broad categories of knowledge and skills. At the elementary level the current categories are Problem Solving, Understanding of Concepts, Application of Mathematical Procedures, and Communication of Required Knowledge. At the secondary level, the current categories are Knowledge/Understanding, Thinking/Inquiry/Problem Solving, Communication, and Application. (It should be noted that the achievement charts are being revised as part of the Sustaining Quality Curriculum process. One goal is to ensure the alignment of categories in elementary and secondary achievement charts.) The achievement charts describe four levels of student achievement in each category, with level 3 (equivalent to a mark of 70–79 per cent) as the provincial standard.

The Provincial Report Card communicates student achievement to students and parents. Elementary school reporting on mathematics is currently organized by five strands or groupings of curriculum expectations: Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Patterning and Algebra, and Data Management and Probability. At the secondary level, the student receives an overall percentage grade for each course.

The Education Quality and Accountability Office conducts annual province-wide tests of student performance in mathematics in Grade 3, in Grade 6, and in the Grade 9 applied and academic programs. These assessments measure how well students are meeting the learning expectations of the curriculum and help schools and parents monitor students' progress and identify those students who need extra support. Boards are required to submit yearly improvement plans for mathematics to the EQAO.

International, National, and Provincial Results

The Organisation for Economic Co-operation and Development (OECD) has initiated the Programme for International Student Assessment (PISA). In the first study, conducted in 2000, Canadian 15-year-olds ranked near the top in mathematical literacy among students from 32 countries (OECD, 2001). Only Korea and Japan performed significantly better than Canada. Approximately 4,000 Ontario students took part and scored slightly below the Canadian average.

In 1999, some 4,000 Ontario Grade 8 students participated in the repeat of the Third International Mathematics and Science Study (TIMSS) first conducted in 1995. The 1999 assessment measured the mathematics and science achievements of eighth-grade students from 38 countries (Mullis et al., 2000). In mathematics, the Ontario students scored significantly higher than the international average in all five content areas: fractions and number sense; measurement; data representation, analysis, and probability; geometry; and algebra (EQAO, 2000). In 1995, Ontario Grade 8 students performed at about the international average overall but scored lower than the international average in geometry, algebra, and measurement.

At the national level, the provinces and territories have established the School Achievement Indicators Program (SAIP) to assess the performance of 13- and 16-year-old students in mathematics, reading and writing, and science. In the SAIP 2001 mathematics assessment, Ontario students performed as well as the Canadian average in both the content and problem-solving components for both age groups. More than 4,800 randomly selected Ontario students participated.

Within Ontario, the EQAO reports assessment results based on the expectations in the curriculum, using the four-level scale. The EQAO conducted the third assessment of Grade 9 mathematics in 2002–2003. In the academic program, 66 per cent of students met the provincial standard – up from 49 per cent in 2000–2001 and 64 per cent in 2001–2002. The results for the applied program are summarized in the table on the next page (EQAO, 2003c).[3]

3. These results are based on EQAO's Method 1, which expresses the number of students in each reporting category as a percentage of all students in the grade – including those in the exempt and no-data categories.

EQAO Assessment Results – Mathematics – Grade 9 Applied

Year	Below Level 1	Level 1 (passable achievement, equivalent to 50–59% mark)	Level 2 (approaching provincial standard, equivalent to 60–69% mark)	Level 3 (provincial standard, equivalent to 70–79% mark)	Level 4 (above provincial standard)
2002–2003	8%	20%	37%	21%	–
2001–2002	8%	19%	37%	21%	–
2000–2001	16%	24%	25%	13%	–

"Success in mathematics in the early grades is critical. Early mathematics understanding has a profound effect on mathematical proficiency in the later years."

(Expert Panel on Early Math in Ontario, 2003, p. 1)

"A sound understanding of mathematics is one that sees the connections within math and between math and the world."

(Consortium of Ontario School Boards, 2003, p.1)

3 What Mathematical Literacy Is

The definition of mathematical literacy has been debated internationally for decades. The Expert Panel feels confident that the broad outline of a vision for mathematical literacy is now widely accepted.

The OECD Programme for International Student Assessment (PISA) (OECD, 1999) defines mathematical literacy as:

> an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgments and to engage in mathematics, in ways that meet the needs of that individual's current and future life as a constructive, concerned and reflective citizen. (p. 41)

"Today's mathematics curriculum must prepare students for their tomorrows. It must equip them with essential mathematical knowledge and skills; with skills of reasoning, problem solving, and communication; and most importantly, with the ability and the incentive to continue learning on their own."

(Ontario Ministry of Education and Training, 1999a, p. 3)

A further study (Bussière, 2001) explains that this definition "revolves around the wider uses of mathematics in people's lives rather than being limited to mechanical operations." Mathematical literacy includes

> the ability to put mathematical knowledge and skills to functional use rather than just mastering them within a school curriculum. To "engage in" mathematics covers not simply physical or social actions (such as deciding how much change to give someone in a shop) but also wider uses, including taking a point of view and appreciating things expressed mathematically (such as having an opinion about a government's spending plans). Mathematical literacy also implies the ability to pose and solve mathematical problems in a variety of situations, as well as the inclination to do so, which often relies on personal traits such as self-confidence and curiosity. (p. 86)

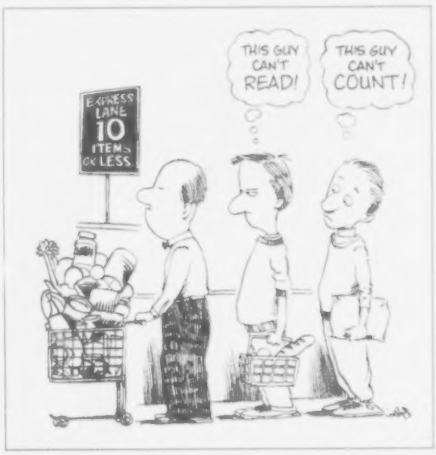
The Expert Panel's vision of mathematical literacy encompasses the ability to:

- estimate in numerical or geometric situations
- know and understand mathematical concepts and procedures
- question, reason, and solve problems
- make connections within mathematics and between mathematics and life
- generate, interpret, and compare data
- communicate mathematical reasoning

As well, the panel's vision includes being engaged in mathematics – that is, understanding the value of mathematics and having the inclination and the confidence to use it.

Mathematics supports decision making in all aspects of life. As Paulos has pointed out, students need the "ability to deal with fundamental notions of number and chance in order to make sense of mathematical information presented in everyday contexts" (1988, p. 3). Moreover, our society places a high economic value on mathematical literacy, as shown by Ontario's requirements for secondary school graduation and entry into postsecondary institutions and apprenticeship programs. Mathematical literacy is increasingly an imperative for employment.

In this climate, the stereotype of mathematics as relevant only to the few is not only outmoded but damaging. Too many adults feel they were not good at mathematics, and do not ask more from their children. Children respond to expectations and these expectations must be raised. Parents, teachers, and all adults must recognize and affirm the importance of mathematical literacy for all.



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Mathematical literacy is closely related to literacy. While literacy is the foundation for all learning, mathematical literacy is also necessary if we are to understand fully the information that surrounds us in modern society.

Mathematical literacy has several dimensions – for example, numerical literacy, spatial literacy, and data literacy – and extends beyond the mathematics classroom to other fields of study. Teachers should take advantage of the abundant opportunities that exist for fostering mathematical literacy across the curriculum. All teachers have a responsibility to communicate the view that all students can and should do mathematics.

> "In the changing world, those who understand and can do mathematics have significant opportunities and options for shaping their future."
>
> *(National Council of Teachers of Mathematics [NCTM], 2000, p. 5)*

4 What Research Tells Us

In preparing this report, the Expert Panel has considered research findings from Canada and other countries. This knowledge base contains valuable insights that can help educators understand the needs of adolescent learners and determine how these needs can be met to foster the development of mathematical literacy. Much research has been done on mathematics learning strategies for the general student population, and a small but growing body of work focuses specifically on at-risk mathematics learners. The Expert Panel has examined both aspects of the research.

The main themes that emerge from our review of the research are as follows:

- **Effective teaching and learning begin with the needs of adolescent students and reflect their developmental stages.**
- **An effective learning experience is one that connects mathematics with the lives of adolescent students.**
- **Students must have a solid conceptual foundation in mathematics in order to apply their knowledge and to continue to learn mathematics.**
- **Effective instructional strategies in mathematics emphasize the ability to think, to solve problems, and to build one's own understandings.**
- **To improve students' performance, teachers should link instruction more closely with assessment.**
- **Teachers of mathematics need professional learning opportunities that strengthen their competence in both mathematics content and the methodology for teaching it.**
- **Technology supports learning and should be accessible to all students – especially those who struggle with mathematics.**
- **To form an effective learning environment in which the needs of all students are met and their success is promoted, schools and school systems need sound planning and strong leadership.**
- **Mathematics learning strategies that benefit all students are a necessity for students at risk, and extra support may also be needed to close the gap.**

Needs of Adolescent Learners

Effective teaching and learning begin with the needs of adolescent students and reflect their developmental stages.

Converging work in pedagogy, cognitive psychology, and brain science has much to offer educators. Studies suggest placing emphasis on how adolescents learn. Teachers have a key role in ascertaining the developmental stage of each student and creating an appropriate learning environment for each. The transition from elementary to secondary school is a significant turning point for adolescents and requires attention and support. Teacher sensitivity to student needs is especially important where at-risk learners are concerned.

Research Findings

Emerging Neuroscience Knowledge

- Neuroscience research describes the teenage brain as a "work in progress". For example, the ability to make sense of the number domain and to have intuitions about numbers rests on a non-verbal representational system. During development, this quantity system becomes linked with various representations of numbers – visual in the form of strings of Arabic digits (e.g., 65), verbal in the form of strings of words (e.g., sixty-five), or conceptual (e.g., 5×13 is $\frac{1}{2}$ of 130). Fluency in arithmetic is based on a constant interplay between these representations of numbers. As adulthood approaches, this complex interplay often develops at different rates in different people. In light of this emerging knowledge, it may be more productive to focus on how to teach knowledge and skills to adolescent learners than on when to teach them (Centre for Educational Research and Innovation [CERI], 2000, 2001; OECD, 2002).

Affective Domain

- Numerous studies have found a positive correlation between attitude and achievement in mathematics (Dossey, Mullis, Lindquist, & Chambers, 1998, as cited in Expert Panel on Early Math in Ontario, 2003).
- It is important for the teacher to help all students feel confident about their ability to learn mathematics. This does not call for making fewer demands, modifying the curriculum, or setting lower standards. Instead, teachers of mathematics need to have a variety of strategies at hand for meeting the challenges of student learning (Posamentier & Stepelman, 1990).
- One of the chief elements of mathematics education reform is teachers who make the development of student self-confidence in mathematics as important as achievement. This aim can be found in Ontario provincial guidelines (Ross, Hogaboam-Gray, & McDougall, 2002).

- *Targeted Implementation and Planning Supports* (TIPS), an Ontario resource for those working with mathematics students in Grades 7–9, cites brain research that suggests there are five "theatres of the mind" – emotional, social, physical, cognitive, and reflective (Given, 2002, as cited in Consortium of Ontario School Boards, 2003). Traditionally, mathematics programs have focused on the cognitive learning system with less attention to the other four areas. However, teachers of mathematics are becoming more aware of the importance of the affective domain – the emotional, social, and reflective learning systems. The intent of TIPS is to help teachers activate all the student's learning systems.
- Students learn in a variety of ways. Some learn best by listening and some by watching; others learn best by doing. Teachers should remember that while students have their preferred modes of sensory input, they still need to develop the other modes. All these modes should be used during lessons so that each student has the opportunity to use his or her strength (Tucker, Singleton, & Weaver, 2001).
- Student questionnaires completed for the 2002–2003 EQAO Grade 9 mathematics assessment gauged student attitudes (EQAO, 2003b). In the applied program, in response to different questions, 23 per cent of students said they liked mathematics, 41 per cent felt it was boring, 39 per cent understood most of the mathematics they were taught, and 28 per cent felt that the mathematics they were learning was very useful for everyday life.
- As with literacy, numeracy performance appears to stagnate or decline as students become disengaged and unmotivated at school (Barber, 1999; Hill & Russell, 1999). The disengaged students may develop mathematical anxiety (Dossel, 1993; Hembree, 1990; Maxwell, 1983; Meyer & Fennema, 1992; Williams, 1988).
- Employing best practices for teaching mathematics helps prevent mathematical anxiety (Furner & Duffy, 2002). To reduce anxiety if it occurs, teachers must help students understand how it came about. Learners must first recognize when the panic starts through signs like going blank, getting nervous, or having sweaty palms. Then they can use techniques such as controlling their breathing, visualizing success, or using positive "I" messages (Tobias, 1987, as cited in Furner & Duffy, 2002).

Adolescent Development

- Adolescent students vary greatly in their development and readiness for learning. Teachers play a critical role in judging the developmental stage of each student and establishing rich environments through which students can explore mathematics at an appropriate developmental level (Reys, Lindquist, Lambdin, Smith, & Suydam, 2003, as cited in Consortium of Ontario School Boards, 2003).
- The adolescent learner is experiencing intellectual, physical, emotional, and social changes. Adolescents may lack self-confidence on the one hand and be eager to test limits on the other. Recognition by peers and social status are extremely important to them.

Teachers can respond to these characteristics by giving students a role in determining classroom rules and procedures; ensuring that students feel safe to take risks and participate during mathematics learning; giving students opportunities to move around and engage in situations kinaesthetically; using a variety of student groupings, for particular purposes; giving students opportunities to discuss and investigate different ways of thinking about and doing mathematics; and providing tasks with multiple entry points to accommodate both concrete and abstract thinkers (Consortium of Ontario School Boards, 2003).

- Adolescent students at risk often experience difficulty during the transition from the teaching style of elementary teachers, who are traditionally student-centred in their approach, to the style of secondary teachers, who are traditionally subject- or discipline-centred (Acker, 1995; Hargreaves, 1994; Whitehead, 2000). A seamless transition from elementary schooling to secondary schooling is crucial for better student learning (Carrington et al., 2001).
- The responsibility for learning must be placed with students if they are going to develop a sense of control over their environment. Supporting young children to make decisions in the mathematics classroom can be the beginning of their empowerment (Carey, Fennema, Carpenter, & Franke, 1995).
- Mathematics achievement in the middle school years is closely linked to the successful establishment of foundational skills in number sense in the first years of schooling. Higher-level conceptual structures depend on core concepts typically acquired at age 5 or 6. Hence students whose core structure is not in place at the expected age will have difficulty catching up (Griffin, 2004).
- Stereotypes about the relative mathematical abilities of boys and girls persist despite evidence to the contrary. In Ontario, for example, males and females performed equally well in the 2002–2003 EQAO province-wide Grade 9 mathematics assessment (EQAO, 2003c).

Making Connections

An effective learning experience connects mathematics with the lives of adolescent students.

Making mathematics meaningful is a key priority for engaging adolescent learners. Research suggests applying mathematics in ways that are linked to students' experiences, curiosity, imagination, and aspirations. Learning must begin with where students are and what they know.

Research Findings

Connectionist Teaching

- A major research study in England – the Effective Teachers of Numeracy Study (Askew, Brown, Rhodes, Johnson, & Wiliam, 1997) – rated teacher effectiveness according to student gains in tests. Teachers' underlying beliefs about teaching and mathematics were a strong differentiating factor between highly effective teachers and other teachers. In the study, teachers were interviewed and three models of teaching orientation emerged. Highly effective teachers were found to be "connectionist": they valued students' methods, used students' understandings, and placed emphasis on making connections within mathematics. Connectionist teachers contrasted with transmission teachers, who viewed mathematics as a collection of skills, conventions, and procedures to be taught and practised. They also differed from discovery teachers, who saw mathematics as being developed by students themselves, particularly through interaction with concrete materials.
- In Michigan, the Connected Mathematics Project (CMP) (1991–1997) focused on having students solve real-world problems, develop and defend their own computational methods, and generalize their findings. Student achievement in problem solving improved, and students also made gains on traditional tests of basic skills (Fey, Fitzgerald, Friel, Lappan, & Phillips, 2003).
- A study on the Australian Middle Years Numeracy Research Project (Siemon, Virgona, & Corneille, 2001) recommended that basic principles for teaching include the following: ensuring that students experience success; encouraging students to speak and listen – to conjecture, generalize and connect; and assisting students to make connections between related topics and processes.

Engaging Students

- Students' engagement in learning depends on studying topics that relate to their own lives. Students report feeling most engaged when they help define the content to be studied; have time to pursue areas of most interest; are encouraged to raise questions and view topics in new ways; have passionate, inventive, and respectful teachers; and sense that their study is open-ended rather than predetermined and predictable (Black, 2003).
- Reaching disengaged students is an ongoing challenge. Success has been reported for teachers who figure out what students know, pose questions, evaluate, and modify their instruction to meet students' needs. Effective teachers then help students apply mathematical knowledge in real contexts, communicate mathematically, and enjoy and like mathematics (Ball, 2000; Shulman, 1986).

Conceptual Foundation

Students must have a solid conceptual foundation in mathematics in order to apply their knowledge effectively and to continue to learn mathematics.

Students need a solid conceptual foundation if they are to connect their mathematics knowledge with real situations and have the confidence to do so. Research shows that in-depth treatment of mathematics topics results in richer conceptual understanding.

Research Findings

In-Depth Learning Crucial

- Some of the key concepts in the mathematics curriculum – ratio and proportion and the related topic of percentage – are notoriously difficult for students in early adolescence. Even though many students can readily learn the calculation skills linked with these topics, they need a strong conceptual foundation in order to apply these skills to solving real problems (Dole, 2000; Dole, Cooper, Baturo, & Conoplia, 1997; Lo & Watanabe, 1997).
- A deeper treatment of traditional mathematics topics is imperative if teachers are to provide students with a foundation for success in the twenty-first century. Lesh and Heger (2001) write:

  > (T)he kind of understandings and abilities that appear to be most needed are not about the introduction of new topics as much as they are about broader, deeper, and higher-order treatments of traditional topics such as rational numbers, proportions, and elementary functions – topics that have been a part of the traditional elementary mathematics curriculum but that have been treated in ways that are far too narrow and shallow. (p. 12)

- The Third International Mathematics and Science Study (TIMSS) (Stigler, Gonzales, Kawanaka, Knoll, & Serrona, 1999) included a Video Study, which videotaped mathematics lessons in classrooms in seven countries: Australia, the Czech Republic, Hong Kong SAR, Japan, Netherlands, Switzerland, and the United States. The TIMSS Video Study report (Hiebert et al., 2003) highlighted the weakness of "shallow teaching", where students follow procedures without reasons. Shallow teaching did not lead to increases in conceptual understanding and problem-solving ability.
- Teachers with little specific mathematics teacher training often teach mathematics the way they were taught the subject (Battista, 1999; Maxwell, 1983). Instruction in such cases usually focuses on drill and practice with little depth and intellectual challenge (Lingard et al., 2001). Students who can accurately and quickly solve routine problems but are unable to apply their knowledge to new and different problems lack a deep-seated understanding of mathematics concepts (Bempechat, 1998).

Instructional Strategies

Effective instructional strategies in mathematics emphasize the ability to think, to solve problems, and the build one's own understanding.

A significant body of research addresses the question of what effective mathematics teaching and learning look like. Successful classroom practices involve higher-order thinking, with an emphasis on problem solving. The teacher's main role is to facilitate learning activities and create a classroom environment that engages students and helps them arrive at an understanding of mathematics.

Research Findings

Lesson Features

- The TIMSS Video Study (Hiebert et al., 2003; Stigler et al., 1999) identified lesson features that correlate positively with improved student learning outcomes:
  - Time is invested in lesson planning (Sternberg & Horvath, 1995).
  - Lessons are structured so that students have a variety of opportunities for learning (Brophy & Good, 1986; Good, Mulryan, & McCaslin, 1992; Grouws & Cebulla, 2000).
  - Each lesson is structured as a coherent whole, with clear goal statements and stated relationships of previous work to new material (Brophy & Good, 1986; Stigler & Perry, 1988).
  - Teachers sequence mathematical problems so that students can see mathematical connections, relationships, and structure in the topic they are studying (Hiebert et al., 2003; Stein & Lane, 1996).
  - Practice is an important aspect of classroom learning but includes a focus on applying new material to new situations (Hanna, 1987).
  - Students are encouraged to find their own solution methods and to examine different solution methods (Grouws & Cebulla, 2000).
  - Teachers provide classroom environments in which high expectations are set, students are encouraged to be self-regulating, and students are engaged in their own learning (Gore, 2000; Nickerson, 1988).
  - For students to develop conceptual understanding and mathematical thinking, they are given tasks that are mathematically challenging and significant (Askew et al., 1997; Faivillig, 2001).

  An analysis of the TIMSS data found that Japanese lessons include high-level mathematics, a clear focus on thinking and problem solving, and an emphasis on having students derive alternative solution methods and explain their solutions (Stigler et al., 1999).
- Mathematics instruction should no longer mean the transmittal of information and procedures from teacher to student. Instead, students must be encouraged to construct their own understandings. This process depends on activities facilitated by the teacher, as well as on the prior knowledge of each individual student (D'Ambrosio, Johnson, & Hobbs, 1995).

- Instructional tasks should provide rich learning opportunities. A "rich task" encourages students to use subject knowledge and skills in ways that are relevant in and beyond the classroom. Rich tasks require students to think in ways they will have to think in life outside school (Flewelling & Higginson, 2001).
- A focus on problem solving is a key component of sound mathematics teaching and learning. "Solving problems is not only a goal of learning mathematics but also a major means of doing so" (NCTM, 2000, p. 52).
- On the basis of an analysis of educational and cognitive research, Chazan and Yerushalmy (2003) describe teaching strategies for the successful learning of middle school algebra:
  - Students should work not only on well-defined tasks but also on ill-defined ones that more closely resemble the ways in which algebraic knowledge is used outside school.
  - Content should focus on a small set of important conceptual chunks – or big ideas – rather than a large number of mechanical symbol manipulations.
  - Instruction should connect with students' experience and build on the resources and strengths that students bring to the classroom.

Manipulatives

- A focus on deep learning of particular mathematics topics – through a variety of strategies, including working with concrete materials – leads to greater conceptual depth (Ben-Chaim, Fey, Fitzgerald, Benedetto, & Miller, 1998; Fletcher, Hope, & Wagner, 2001; Siemon et al., 2001).
- Manipulatives allow students to concretely explore mathematical relationships that will later be translated into symbolic form. The key to the successful use of manipulatives lies in the bridge – which must be built by the teacher – between the artifact and the underlying mathematical concepts (D'Ambrosio et al., 1993). The mathematics is in the connections, not the objects (Kilpatrick & Swafford, 2002).
- Studies on the use of manipulatives by students described as low achievers, at risk, having behaviour problems, or with limited English proficiency have found positive effects on achievement (Ruzic & O'Connell, 2004).

Cooperative Learning

- Cooperative learning can make a strong contribution towards creating an enriched environment, but it is more than just putting students into groups. It is learning and working together towards a common goal (Haylock & D'Eon, 1999).
- Deliberate and planned instruction in social skills is usually necessary in order for cooperation among group members to occur (Ronis, 1999).
- Extensive research on cooperative grouping indicates that such groupings are likely to have positive effects on achievement and other social and psychological characteristics. However, certain implementation standards, such as the combining of individual accountability with group goal setting, must be present (Kilpatrick, Swafford, & Findell, 2001).

ASSESSMENT

To improve students' performance, teachers should link instruction more closely with assessment.

Teachers should link assessment and instruction, to provide ongoing feedback to students and inform teaching practice. Assessment should reflect instruction. Teachers need to adapt their assessment plans to ensure that the needs of all learners are met.

Research Findings

Purpose of Assessment

- The purpose of assessment is to improve student learning by providing feedback and generating data to inform and guide instruction. Research indicates that linking assessment and instruction on a daily basis increases students' knowledge (Black & Wiliam, 1998). As instructional strategies become more diverse – including open-ended investigations, cooperative group activity, and emphasis on thinking and communication – the form of assessment must also change (Stenmark, 1991). Multiple strategies – such as observations, portfolios, journals, rubrics, tests, projects, self-assessments, and peer assessments – tell students that the teacher appreciates their daily contributions and does not base evaluations solely on test results (Consortium of Ontario School Boards, 2003).
- Information gathered through assessment helps teachers determine students' strengths and weaknesses in achieving the curriculum expectations. As part of assessment, teachers provide students with descriptive feedback that guides their efforts to improve (Ontario Ministry of Education, 2000).

Authentic Practices

- Reform-oriented mathematics educators have in many cases attempted to find more authentic or real-world ways to assess student achievement. A corresponding shift has taken place in mathematics teaching. Emphasis is increasingly placed on the process of learning (examining, analysing, exploring alternative routes to solutions) rather than the products of learning (the grade, the one right answer) (Bempechat, 1998).
- The Australian Middle Years Numeracy Research Project study emphasized that assessment should include rich tasks that can authentically measure students' numeracy (Siemon et al., 2001).
- Assessment practices that promote equity measure the success of all learners by methods that offer the best opportunity for students to demonstrate their mathematical capabilities (Telese, 1998).

Professional Learning

Teachers of mathematics need professional learning opportunities that strengthen their competence in both mathematics content and the methodology for teaching it.

Effective teaching is critical for the improvement of student learning. For this reason content knowledge among teachers of mathematics is a key issue. Teachers' approaches to the teaching of mathematics have also been cited as a major factor in student success. If improvement in student achievement is to be continuous, teachers must have access to ongoing and comprehensive professional learning in mathematics and the best ways to teach mathematics.

Research Findings

Link to Student Success

- Teacher knowledge about the teaching and learning process is the most powerful predictor of student success (Greenwald, Hedges, & Laine, 1996; Marzano, 1998).
- The Michigan Connected Mathematics Project (CMP) called on teachers to change the way they taught, so that students could learn mathematics by exploring concepts through solving problems and connecting and generalizing their findings. The positive results of the CMP suggest that, to succeed, students require teachers with a high level of competence in teaching methods specific to mathematics. Other studies have also called for professional development programs aimed at extending both teachers' content knowledge and pedagogic approaches specific to that content (Darling-Hammond, 2000a, 2000b; National Staff Development Council, 1997).
- In England, the Office for Standards in Education (OFSTED) periodically evaluates the National Numeracy Strategy launched in 1999. A 2001 report observed that the quality of staffing was the most important factor in determining success, but far too many teachers had limited subject knowledge of mathematics. Teaching staff with limited specialist expertise in mathematics needed more training and support. The next report, in 2002, found continued weaknesses in teachers' ability to help students overcome their difficulties and improve their understanding. OFSTED said the national strategy was correct to give priority to providing more five-day training courses to improve teachers' subject knowledge.
- As was noted earlier, the Effective Teachers of Numeracy Study (Askew et al., 1997) classified highly effective teachers as connectionist. Long-term professional development courses of 10 days or more, with a focus on student conceptions and strategies, were the strongest background factor marking connectionist teachers.
- The RAND Mathematics Study Panel (2003) has proposed a research focus on developing teachers' mathematical knowledge in ways that are directly useful for teaching. Research is also necessary to develop improved means for making mathematical knowledge that is useful and usable for teaching available to teachers.

Focus on At-Risk Learners

- Research has shown that a powerful and negative chain reaction commonly occurs where teachers are working with at-risk learners (Baker, 1999; Marchesi, 1998). This dangerous cycle often involves the following: poor behaviour patterns among students who have been unsuccessful in the past; a corresponding lack of instructional confidence among teachers; the development of negative expectations for these students; decreased interaction with, and attention to, these students; and then a perception on the part of struggling learners that they are being discriminated against, leading to further failure. Professional development can help modify this situation by fostering changes in teachers' outlook. Teachers must believe that it is possible to educate all students and that the education authorities have provided enough support to do this. Teachers must believe they can achieve this goal. And finally, they must believe that teaching children with greater learning difficulties is worthwhile (Marchesi, 1998).

Information and Communication Technologies

Technology supports learning and should be accessible to all students – especially those who struggle with mathematics.

Technology can be used to reduce the time taken on routine mathematical tasks and promote thinking and concept development. All students, especially students at risk, should have access to learning environments supported by information and communication technologies (ICT).

Research Findings

Taking Advantage of ICT

- Capitalizing on students' skills with popular technologies can be an avenue for bypassing the tedium of computational exercises, so that school mathematics provides opportunities for problem solving and thinking (Battista, 1999; Lesh & Heger, 2001; Noss, 1998).
- Evaluation of England's National Numeracy Strategy has underlined the need for schools to give more emphasis to ICT to enhance learning in mathematics. In its report after the third year of the strategy, OFSTED noted that improving teachers' expertise and confidence in using ICT continued to be a challenge for many schools. The most common and successful uses of ICT in mathematics teaching were programmable robots for work on angles and direction; data-handling software; and programs to help students practise number skills (OFSTED, 2002).
- Merely integrating technology into the curriculum will not improve student performance on its own. Thoughtful and appropriate selection of how and where technology should be integrated is essential (Charp, 2000).

Access to Technology

- Ontario teachers complete questionnaires in connection with the province-wide Grade 9 mathematics assessments. For the 2002–2003 assessment, 63 per cent of teachers reporting on the applied program indicated that their students had access to computers at school during the course only a few times, never, or hardly ever. Fifty-one per cent of these teachers also reported having similar limited access to graphing calculators (EQAO, 2003c).
- A researcher examining the potential role of technology in an algebra course emphasized the need for increased access to technology if students are to have opportunities to acquire skills in the appropriate use and application of these learning tools (Pugalee, 2001a).
- Technology has high potential for at-risk children, provided basic conditions are met – for example: sufficient numbers of computers available in classrooms; in-school curriculum and technology support; and extensive training for teachers and staff on software, classroom management strategies, parent involvement, cultural diversity, and the teaching of children who live in poverty (Moore, Laffey, Espinosa, & Lodree, 2002).

Leadership and Planning

To form an effective learning environment in which the needs of all students are met and their success is promoted, schools and school systems need sound planning and strong leadership.

While the role of the teacher is pivotal, strong leadership is also required to improve mathematical achievement. Planning at the school level is invaluable. Progress depends on a pervasive commitment to success for every student by parents, teachers, and administrators.

Research Findings

A Shared Vision

- Students at risk are greatly influenced by the complex network of relationships inside schools. A study for the U.S. Office of Educational Research and Improvement (Rossi & Stringfield, 1995) identified the following overarching conditions that schools must meet in order to increase the likelihood of success for at-risk students: shared vision; shared sense of purpose; shared values; incorporation of diversity; communication; participation; caring; trust; teamwork; and respect and recognition.
- The following factors have been identified as key elements in improved student learning: a clearly articulated and shared vision, dispersed leadership across people and tasks, and organizational structures that enable collaborative teamwork among staff (Christie & Lingard, 2001; Crowther, Kaagan, Ferguson,

& Hann, 2002; King, Louis, Marks, & Peterson, 1996; Kruse & Seashore-Louis, 1997; Land, 1998; Leithwood, Jantzi, & Steinbach, 1999).

- The results from the 2000 Programme for International Student Assessment (PISA) can be used to gauge the relative performance of schools across Canada. The most important characteristics of a successful school are the social and disciplinary climate of the classroom, teacher-student relations, and the school's emphasis on academic achievement (Willms, 2003).

Focused Leadership

- The Middle Years Numeracy Research Project study emphasized the importance of effective leadership and coordination. Teachers alone, while a vital ingredient, were not enough to achieve progress in numeracy development. Schools engaged in whole-school numeracy planning recorded an increase in numeracy performance for all students and especially for students at risk (Siemon et al., 2001).
- School restructuring, reorganization, and culture changes may not translate into improved student outcomes without a specific leadership focus on pedagogy and curriculum (Newmann et al., 1996; Newmann, King, & Rigdon, 1997).
- Fullan (1997) highlighted the important and complex role of administrators and system leaders in the face of change and educational reform:

  > Leaders must foster a climate where people are able to work with polar opposites; push for valued change while allowing self-learning to unfold; see problems as sources of creative resolution; have good ideas but not be blinded by them; and strive for internal cohesion as they are externally oriented. (p. 16)

Students at Risk in Mathematics

Mathematics learning strategies that benefit all students are a necessity for students at risk, and extra support may also be needed to close the gap.

All students benefit from instructional and assessment strategies that reflect the latest thinking about mathematics teaching and learning. For students at risk, the best strategies are a necessity. Intervention programs help students at risk close the remaining gap. Professional learning can give teachers the tools to address the needs of at-risk students. Support from the community as a whole fosters success for all.

Research Findings

Learners' Characteristics

- At-risk students are not experiencing success in school, exhibit low self-esteem, have a minimal identification with the school, and may have problems that prevent them from participating successfully. As they fall behind their peers, school becomes a negative environment that reinforces their low self-esteem (Bauer, Sapp, & Johnson, 2000; Donnelly, 1987; Vatter, 1992).

- At-risk students are caught up in a cycle of perceived failure and have difficulty breaking out of it. Vatter (1992) observed that "many of these students are so accustomed to failure that they don't believe their success, even when it has been pointed out to them" (p. 292). He suggested that at-risk students could be helped to find some success if (1) schoolwork is hands-on; (2) students' feelings of worth and accomplishment are nurtured by the work itself; and (3) the work is tied to real work in the real world.
- Teacher relationships with students can have a strong impact. Many educators who have enabled high-risk students to succeed have done so because they "concentrate on students' strengths, show compassion for their lives, believe in them and their families and 'welcome them at the table'" (Williams, 1996).

Instructional and Assessment Practices

- A large-scale U.S. study of 150 Grade 1 to Grade 6 classrooms contradicted the view that disadvantaged students should not engage in academically challenging work until they have mastered basic mathematical skills. One set of classrooms used a conventional computation-oriented curriculum. Other classrooms stressed conceptual understanding and expanded the range of mathematics topics beyond arithmetic. In the latter group, teachers presented mathematical ideas in multiple ways, used non-routine problems to apply concepts, and held classroom discussions requiring logical reasoning to explore alternative solutions. Students in the latter group performed substantially better than those in conventional classrooms (Knapp, Shields, & Turnbull, 1995, as cited in Kilpatrick & Swafford, 2002).
- Low-achieving students suffer most from a proficiency-driven curriculum. Schools postpone instruction in higher-order thinking skills until basic, low-level skills have been mastered. As a result, these students face dull drill and repetition indefinitely and never seem to grasp the underlying concepts (Ronis, 1999).
- Teachers of students at risk should attempt to organize and structure material in a way that gives meaning to learning and helps students learn for themselves. Teachers should share the significance of learning with students using whatever communication systems work. They should also plan classroom activities so that classmates stimulate the construction of knowledge, either by working in groups or with more knowledgeable students as tutors (Marchesi, 1998).
- At-risk students' success has been attributed to a more hands-on, project-based approach to curriculum involving increased student choice, flexibility, and connections with students' everyday lives (Vatter, 1992).
- Students with limited vocabulary and language structure may need help with key words required to communicate mathematical ideas. For example, they may be unfamiliar with words such as *either*, *each*, *altogether*, and *between*. Teachers can assist by presenting problems in multiple formats and by encouraging student-to-student discussion about the problem before students work on a solution (Haylock & D'Eon, 1999).

- Effective teachers help students at risk retrace their thinking back to the point where meaning became lost. They then help students see links between their own prior knowledge and new knowledge (Sullivan & Clarke, 1991).
- A teacher has documented her personal journey to "reinvent herself" after moving from a school with many high-achieving students, where her teaching strategies were highly effective, to a school with a large population of at-risk students, where her previous methods at first failed dismally (Robert, 2002). Through accommodations such as increased scaffolding and incremental positive feedback to students, she again experienced success. She was able to offer challenging curricular projects and maintain high standards in her classroom.
- Students must regularly be given the opportunity to struggle with mathematics problems. By denying them these experiences, or by providing excessive assistance to shelter them from what is perceived as mental pain, teachers and parents can end up "crippling kids with kindness" (Chatterley & Peck, 1995). As Martinez and Martinez (2003) note, "In fact, the body and the mind need stress to grow and function.... To change *distress* [negative stress] to *eustress* [positive stress] may require a change in the stress-producing conditions" (p. 29).
- Students who are struggling with mathematics may require assessment accommodations. These might include more time to complete tasks, oral rather than written assessment, or observation of achievement during instruction rather than the assignment of paper-and-pencil tasks. In all cases, assessment accommodations are not a "watering down" of the process but an opportunity for students to show what they know and can do in a way other than originally planned (Consortium of Ontario School Boards, 2003).

Intervention Programs

- The Counting On project in Australia – an intensive intervention program to promote numeracy achievement for students at risk in Grade 7 – specifically targeted the topics of multiplication, division, and place value (Perry & Howard, 2000). Teachers attended professional development days that focused on the targeted topics and included diagnostic techniques and assessment procedures. Results showed significant improvement in student learning outcomes in the targeted areas.
- Improving Numeracy for Indigenous Students in Secondary Schools, a Tasmanian initiative, stresses intensive professional development to introduce teachers to open investigations and group problem-solving activities. Teachers are provided with innovative tasks posing realistic, mathematically rich problems for students to solve, as well as rich assessment tasks and scoring rubrics. Initial results show that the program is achieving the goal of improved numeracy outcomes for Aboriginal students (Callingham & Griffin, 2001; Callingham, Griffin, & Corneille, 1999; Doig, 2001).

- The establishment of counselling groups for at-risk students in schools is often an important part of breaking the cycle of failure that these students may experience. Bauer et al. (2000) describe the group counselling experience as follows:

  > If at-risk adolescents are supported by creating environments in which they can more effectively explore options and problem solve and explore feelings, the safe atmosphere of the counseling group offers opportunities for students to honestly and openly confront fears, anxieties, and myths concerning their lives and futures. In this situation, students can address invalid, inaccurate assumptions about their lives and make initial steps toward reversing their ineffective decisions. (p. 49)

- A Saskatchewan school with 80 per cent of students designated as at risk strives to ensure that students feel valued. The school stresses mentorship by using former students as youth leaders and group facilitators. It fosters opportunities for the public to value students by using community resource people in the school as much as possible (Wotherspoon & Schissel, 2001).

5 Closing the Gap: Instructional and Assessment Strategies

"International comparisons indicate that the most powerful instrument for change in student performance is improved teaching."

(Sutton & Krueger, 2002, p. 41)

At-risk students often learn in ways different from those currently used to teach them. As a result, they fall behind their peers in learning and often motivation. Improved teaching can close the gap and help these students move forward. Strategies range from simple to complex, from short to long term. To enhance student achievement, teachers must become consciously skilled in the art and science of teaching (Bennett & Rolheiser, 2001). Collaboration among teachers through ongoing professional dialogue is invaluable in refining and applying strategies.

Support can be found in *Targeted Implementation and Planning Supports: Grades 7, 8, and 9 Applied Mathematics* (TIPS) (Consortium of Ontario School Boards, 2003). This in-depth Ontario resource is designed to assist beginning teachers, provide new insights for experienced teachers, and help principals and professional development providers as they work to improve mathematics education. The instructional and assessment strategies described in TIPS provide a solid foundation for improved teaching and learning of mathematics for all students.

Research indicates that some of the instructional and assessment strategies featured in TIPS are particularly effective at closing the gap for at-risk learners. To improve their practice, teachers require an understanding of these strategies as well as their impact on at-risk learners and ways to start implementing them. Student Success Leaders, principals, and other administrators must also become familiar with these strategies as a first step in making informed decisions about resource allocation and supports for improved teaching.

The following sections outline strategies that benefit all students but are necessary for at-risk students. The overriding goals are to establish a positive classroom climate and to plan and deliver effective classroom instruction and assessment. While painting a big picture, the descriptions show how to begin with small steps along the path to closing gaps for at-risk learners.

Even with these strategies in place, it is likely some students will still need more time or opportunities to build understanding outside regular classroom hours. A final strategy calls for targeted support for at-risk learners to further close the gap.

Good for all, necessary for some.

Establishing a Positive Classroom Climate

Valuing Mathematics

Valuing mathematics implies being productively disposed towards the subject. It involves seeing mathematics as sensible, useful, and worthwhile, and seeing oneself as able to learn and use it. Teachers must create a climate whereby all students can make sense of the mathematics they are learning and gain confidence in their mathematical ability.

It is important for teachers to model the belief that all students can learn mathematics. Positive teacher attitudes will build students' confidence, help students feel more in control of their own learning, and foster their resilience in the face of challenging problems.

How does this close the gap for at-risk students?

Many at-risk students have a negative outlook about mathematics, often because of their ongoing struggles in the subject or because of the low expectations that teachers and parents may have for their success in mathematics. A positive classroom climate can foster positive attitudes in at-risk students.

Starting Points for Teachers

- Demonstrate a positive disposition towards mathematics.
- Discuss students' feelings about mathematics and build confidence in their ability to learn and use important mathematics.
- Be sensitive to and avoid the verbal and non-verbal ways that adults communicate low expectations for at-risk students.

- Develop and deliver instruction and follow-up tasks that enable at-risk students to make sense of skills and concepts, flexibly changing tactics if at-risk learners are not keeping up.
- Provide supports and follow-up that are engaging to students and support understanding of concepts and skills – for example, games, software, manipulatives.

"Success in mathematics learning requires being positively disposed toward the subject."

(Kilpatrick & Swafford, 2002, p. 16)

Cooperative Learning

Cooperative learning involves more than just organizing students into groups; it involves having students learn and work together towards a common goal. Successful cooperative learning includes five elements: positive interdependence, face-to-face interaction, individual and group accountability, interpersonal and small-group skills, and group processing (Johnson & Johnson, 1994, as cited in Bennett & Rolheiser, 2001).

Social skills – such as encouraging others, disagreeing in an agreeable way, taking turns, including all participants, active listening, and summarizing – play a valuable role in mathematics learning. Using these social skills, students can clarify their thinking, make connections, and recall specific mathematics skills, strategies, or concepts.

How does this close the gap for at-risk students?

At-risk students tend to participate in whole-class instruction only passively. Working in small groups reduces the isolation of the individual and allows at-risk students opportunities to share their ideas in a less-threatening environment. In addition, students can receive immediate feedback and support from one another, rather than depending solely on the teacher.

Starting Points for Teachers

- Involve students in determining appropriate interpersonal and small-group skills.
- Begin with pairs or with groups of three.
- Use strategies like think-pair-share.
- Use cooperative learning strategies frequently but for short periods of time.
- Provide at-risk students with time and strategies for recording the ideas discussed in groups.

"The kinds of experiences teachers provide clearly play a major role in determining the extent and quality of students' learning.... Classroom discourse and social interaction can be used to promote the recognition of connections among ideas and the reorganization of knowledge (Lampert, 1986)."

(NCTM, 2000, p. 21)

Appropriate Classroom Management

Solving problems in the mathematics classroom involves risk taking. Students do not want to be embarrassed in front of their peers, and will not take risks unless they feel valued and supported. The classroom therefore must be a safe place. Schools and classrooms should establish routines that value such behaviours as attentive listening, appreciation, respect, and participation, and that leave no occasion for put-downs (Gibbs, 2001; Pugalee, 2001b).

How does this close the gap for at-risk students?

At-risk students generally feel vulnerable and unable to take risks in the mathematics classroom. Sometimes just showing up takes courage. Establishing routines that foster emotional safety is a crucial step towards creating an environment in which at-risk students will begin to flourish.

Starting Points for Teachers

- Develop effective classroom routines together with students and revisit the routines as necessary.
- Use instructional strategies that increase emotional safety – for example, framing questions appropriately, inviting rather than demanding responses, using well-planned student groupings.
- Use positive humour frequently.
- Recognize that, at times, adolescent students will behave inappropriately and develop a range of strategies for responding – for example, speak privately to students about inappropriate behaviour and use a tone of voice that is neutral, not angry.

> "To allow for a state of 'relaxed alertness' where optimum learning can occur, it is necessary to have a relaxed nervous system and a sense of security – or in teaching terms, a safe, non-threatening classroom environment that values risk-taking."
>
> *(Ronis, 1999, p. 5)*

Attending to the Whole Student

Many at-risk learners feel invisible in the mathematics classroom; others act out in order to be noticed. Whole-class instruction at a pace that leaves struggling learners behind makes them wonder why they should even attend. Teachers should view all students as individuals with strengths, interests, and important perspectives beyond and including mathematics. Students need to know that they are valued as part of the class by the teacher and by peers and that they are missed when they are absent.

How does this close the gap for at-risk students?

When at-risk learners know that the teacher sees the whole person, they are more likely to accept the teacher's support and attend regularly. For example, the teacher could notice and comment on absences in a non-threatening way and explain how

the teacher, the class, or a group missed the student's involvement. In this way, the teacher shows at-risk students that they are valued members of a learning community.

Starting Points for Teachers

- Pay special attention to the personal qualities and interests of at-risk learners, making regular, sincere, positive comments.
- Regularly discuss the circumstances of individual at-risk learners with other educators (e.g., classroom teachers, special education teachers, school administrators) as well as with parents and any community services working with the learner.
- Acknowledge every absence of an at-risk learner in a positive way, making helpful suggestions on how to catch up missed work.

"The emotional part of the brain can hijack the thinking part in a moment's notice."

(Bennett & Rolheiser, 2001, p. 368)

Planning and Delivering Effective Classroom Instruction and Assessment

Making Explicit Links to Literacy

Traditionally, mathematics education has been very procedure-based. Over the past decade, international mathematics reform has placed more emphasis on literacy competencies and their links with mathematics learning. This shift, which has influenced both pedagogy and curriculum expectations, has increased the overlap between literacy skills and mathematics learning in instructional practice.

Research about how children learn shows that if they cannot talk about their learning, they do not own it. Research in social constructivism suggests that groups of students construct knowledge together through critical conversations, that is, by discussing problems worth talking about (Cobb, Boufi, McClain, & Whitenack, 1997). Marilyn Burns (1995) uses the phrase "inking your thinking", observing that when students write their thinking, they sort, clarify, and refine their ideas.

How does this close the gap for at-risk students?

Many at-risk students have weak reading and writing skills, and weak oral communication skills. This lack of skills is a barrier to success in the problem-solving approach required in current mathematics teaching and learning. Weak literacy skills can mask a student's mathematical understanding and can often deny that student even an entry level to problem solving.

Teaching at-risk students the literacy skills necessary for mathematics (e.g., understanding the meanings of words and symbols, unpacking dense text) equips students to undertake new learning, to consolidate learning, and to demonstrate learning. The effective use of literacy skills in mathematics helps students construct their own understanding by increasing their ability to organize and connect "chunks" of knowledge.

Starting Points for Teachers

- Use strategies from *Think Literacy: Cross-Curricular Approaches, Grades 7–12* (*Think Literacy*, 2003).
- Use strategies to develop vocabulary and comprehension skills (e.g., word walls).
- Use strategies relating to the organization of information (e.g., concept maps).
- Use strategies to help students understand features of textbooks and graphics.
- Read problems aloud and highlight key words.

"Mathematics is the most difficult content area material to read because there are more concepts per word, per sentence, and per paragraph than in any other subject; the mixture of words, numerals, letters, symbols, and graphics requires the reader to shift from one type of vocabulary to another."

(Braselton & Decker, 1994, p. 276)

Developing Effective Lessons Focused on Important Mathematics

Effective lessons establish a clear purpose and objectives for both teacher and students. They connect with students' prior knowledge, capture students' interest, and provide opportunities for meaningful practice inside and outside the classroom. Effective lessons enable students to provide meaningful input and summarize the learning, with the teacher as facilitator. In developing lesson plans, teachers anticipate student responses and build in ways to check for understanding and adjust instruction as needed.

The lesson purpose and objectives should target important mathematical concepts and processes. Student action should focus on solving problems. The teacher helps students make connections within mathematics and between mathematics and the world and develop lifelong learning skills. The more that connections are made among a network of ideas, the stronger will be the student's understanding and the less pressure will there be on the student to memorize and to worry about forgetting.

How does this close the gap for at-risk students?

Through lesson planning, teachers anticipate the needs of at-risk learners and provide a variety of strategies and materials to reach students through concrete, visual, and abstract reasoning. Teachers determine how to help at-risk students consolidate their understanding of the processes and concepts of important mathematics. Without consolidation, mathematics remains a set of isolated facts and algorithms, unconnected to the at-risk learner's world. Students at risk are more likely to become engaged and develop connections when they have opportunities to cooperatively solve problems through active lessons.

Starting Points for Teachers

- Build mathematics programs around important mathematics (Weiss & Pasley, 2004).
- Use an effective framework for developing lessons (e.g., the TIPS MATCH lesson-planning template – Minds on, Action, Timing, Consolidate, Home activity or further classroom consolidation [Consortium of Ontario School Boards, 2003]).
- Introduce most skills and concepts through problem solving.

"Comparative studies have shown that the connectionist orientation to teaching produces the most growth in student achievement in mathematics."

(Doctorow, 2002, p. 24)

Making Available and Using a Rich Array of Technologies

In an effective mathematics program, students learn in the presence of technology. Technology should influence the mathematics content taught and how it is taught. Powerful assistive and enabling computer and handheld technologies should be used seamlessly in teaching, learning, and assessment.

Society has evolved from the industrial age to the information age. The industrial-style classroom is obsolete. Schools must seize the opportunity to integrate technology into the learning environment in effective and powerful ways that support improved student learning.

How does this close the gap for at-risk students?

Many struggling students are weak in computational skills and conceptual understanding. By giving at-risk students continuous access to calculators (Grades 7–8) or graphing calculators (Grades 9–12), teachers enable them to participate fully in problem-solving activity that requires computational proficiency. This ensures that they do not fall even further behind. Teachers can assess students' understanding of computational operations by asking students to communicate procedures and to explain the rationale for the various steps.

Assistive and enabling computer technologies allow struggling learners to engage fully in meaningful learning of important mathematics. Dynamic statistics software and dynamic geometry software bring the worlds of data and geometry to life for tactile and visual learners.

Technologies that focus on the communication of knowledge can be valuable accommodations for students with Individual Education Plans. For example, assistive and adaptive technologies like text-to-voice and voice-to-text software can help students acquire skills and demonstrate learning.

Starting Points for Teachers

- Make technologies (calculators, ministry-licensed software, probes) readily available to at-risk students during learning and assessment.
- Have students use ready-made sketches that are available in dynamic geometry software, so that they can focus on reasoning and communication rather than spend time constructing the model.
- Use data that are authentic, relevant, and engaging to at-risk learners, together with dynamic statistical software.
- Ensure that students with IEPs have ready access to the accommodations listed in their plans.

"Now we must find ways to make major mathematical ideas learnable by the large majority of people, infinitely more diverse than the geniuses who originally built them. Fortunately we are no longer constrained by static, inert media – unless we choose to be."

(Kaput, 1998, p. 149)

"The use of technology can improve the literacy, math and science skills of students, including students at risk of school failure, by engaging them in reality-based, multi-disciplinary tasks."

(Edvancenet, n. d.)

Making Available and Using a Rich Array of Manipulatives

Manipulatives are necessary tools for supporting the effective learning of mathematics by all students. These learning materials invite teachers and students to explore and represent abstract mathematical ideas in varied, concrete, tactile, and visually rich ways.

The following table lists essential manipulatives. Many non-commercial manipulatives found at home are also valuable for instruction.

Manipulative	Grades
Algebra tiles (2 colour) – class set, clear plastic organizer trays, overhead or magnetic set	7–10
Base-ten materials (clearview with interlocking pieces)	7, 8
Calculators with fraction key and problem solving	7, 8
Circular fraction set and frames (decimal, degree, percentage, time, fraction, and compass points), translucent pieces and overhead set	7, 8
Coloured tiles and overhead set	7, 8, 9
Coloured relational rods and overhead set	7, 8, 9
Connecting cubes (1 cm, 2 cm)	7, 8, 9
Connecting plastic shapes to build 2-D shapes and nets for 3-D solids	7, 8, 9

Manipulative	Grades
Full circle protractors	7, 8, 9
Geoboards (minimum of 15 cm by 15 cm dimensions) clear 11 × 11, 5 × 5, circular, elastics	7, 8, 9
Geolegs	7, 8
Graphing calculators, preferably with projection capabilities	9–12
Measuring cups	7, 8
Measuring tapes (minimum 150 cm wind-up tape in protective case calibrated in centimetres and millimetres)	7, 8, 9
Metre sticks (unbreakable plastic calibrated in centimetres and millimetres)	7–12
Motion sensor	9–12
Number cubes: 6-sided in two colours; 10-, 12-, and 30-sided	7, 8, 9
Operation cubes (cubes labelled with operation signs)	7, 8, 9
Overhead graphing calculator with projection unit	9–12
Pattern blocks and overhead set	7–10
Pentominoes	7, 8
Plastic transparent tools	7, 8
Playing cards	7, 8, 9
Relational geometric 3-D solids and large demonstration set	7, 8, 9
Rulers, 30 cm	7–12
Safety compasses	7, 8
Spinners (number, colour)	7, 8
Tangrams	7, 8, 9
Trundle wheels	7, 8
Two-colour counters and overhead set	7, 8

How does this help close the gap for at-risk students?

Manipulatives support the conceptual development of important mathematical ideas for tactile and visual learners. Manipulatives allow teachers to provide alternative ways for students to see and think about mathematical concepts. Paper-and-pencil drill does not lead to conceptual learning for at-risk students, but effective use of manipulatives can.

"Manipulatives should be used effectively and selectively as a means of facilitating the ongoing transition from the concrete (physical and visual) stage in student learning, to the more abstract knowledge and deep understanding."

(Consortium of Ontario School Boards, 2003, p. 29)

Starting Points for Teachers

- Begin by selecting one major mathematical idea (e.g., fractions) and exploring that idea with students from many different perspectives, employing a variety of manipulatives.

- Plan how the mathematics concept will be developed from the experience with the manipulatives.
- Plan the assessment of students' mathematics knowledge with and without the presence of the manipulatives.

Focusing on Assessment *for* Learning as well as Assessment *of* Learning

Ontario schools must be re-cultured to reflect the principle that all students can become mathematically literate. This re-culturing requires a shift in thinking about learning. Learning must be seen as gradual and incremental – as the process of closing the gap between a current level of performance and a desired level. For some students, this takes more time, more effort, and more feedback. A concurrent shift in thinking about assessment is also necessary. For many teachers, the kind of assessment that currently predominates is assessment *of* learning, used to report to parents that learning has (or has not) taken place. This is typically done at the end of a unit or course, and students receive feedback in the form of marks or grades.

Assessment *for* learning puts the focus on using diagnostic assessment immediately before learning and formative assessment in the middle of learning to plan and adjust instruction. The emphasis moves from making judgements to coaching students and planning the next steps in teaching and learning.

Teachers are applying assessment *for* learning when they:

- use diagnostic assessment to plan instruction;
- modify instruction on the spot, on the basis of observations of students' body language, discussions with classmates, or questions and answers;
- use alternative instructional approaches based on what they learn from observing students' work;
- plan to revisit a particular big idea later in the program if the concept is not as well understood as it should be;
- provide ongoing feedback to students as they develop new skills and concepts.

To be effective as assessment *for* learning, feedback must include *exactly* what the learner has done well, what he or she has been less successful in doing, and a brief indication of how to improve. Students who are given comments only – rather than marks or marks and comments – make more gains in achievement and feel more positive about the experience (Butler, 1998). Research indicates that oral feedback is more effective than written feedback, particularly for low-achieving, at-risk students (James, McCormick, & Wiliam, n.d.).

A focus on *process* goals is often more helpful than a focus on *product* goals. Feedback on progress over a number of attempts is more effective than feedback on performance treated as an isolated event.

How does this close the gap for at-risk students?

Using diagnostic assessment made shortly before a new concept or skill is introduced, teachers can give at-risk students feedback and an opportunity to close gaps, thereby setting the stage for success. Teachers can also begin instruction in a place and in a way that will meet students where they are and move them forward. Evidence suggests that formative assessment through feedback can improve the performance of low-achievers more than that of other students (Weeden & Winter, 1999).

Starting Points for Teachers

- Increase the use of informal formative assessment strategies – questioning, observations, investigations, demonstrations, interviews, journals – and provide oral feedback focused on mathematical processes.
- Try to catch students being successful. Researchers estimate that a student needs to be successful about 70 per cent of the time for continued engagement to be considered both (a) *challenging* enough to warrant the expenditure of effort and (b) *easy* enough for the student to believe that he or she will experience success (Dickinson & Butt, 1989, as cited in Middleton & Spanias, 2002).

"Tasks built around narrow learning targets of knowledge, techniques, and skills provide students, including low achievers, with no satisfaction or incentive for learning (particularly if their most frequent experience is of getting the answers wrong)."

(Haylock & D'Eon, 1999, p. 12)

Supporting Different Ways of Learning and Demonstrating Understanding

Students learn in different ways. It is important for teachers to incorporate a variety of instructional and assessment strategies in mathematics programs and lessons. This will ensure that all students have opportunities to learn and demonstrate their understanding (Strong, Thomas, Perini, & Silver, 2004).

Differentiated instruction **does not** include:

- doing something different for every student in the class;
- disorderly and undisciplined student activity;
- using groups that never change, isolating at-risk students within the class;
- never engaging in whole-class activities with all students doing the same thing.

Differentiated instruction **does** include:

- using a variety of groupings to meet student needs;
- providing some choice in instruction/assessment activities;
- challenging students to an appropriate level, in light of their readiness, interests, and learning profiles.

Teachers must be observers of their students and make adjustments in their instruction and assessment on the basis of what they observe. Teachers should plan alternative approaches to content, processes, and products.

How does this close the gap for at-risk students?

If a teacher always teaches all students the same things, in the same way, at the same time, the needs of at-risk learners likely will not be met. By differentiating instruction and assessment, the teacher can address the learning needs of more students.

Processes can be differentiated by allowing at-risk students to learn in their preferred learning style. *Products* can be differentiated by providing opportunities for struggling students to demonstrate knowledge and understanding in a variety of ways, rather than solely through traditional pencil-and-paper tasks. *Mathematical models* can be differentiated by teaching students how to work with alternatives such as numerical models, verbal descriptions, physical models, graphical organizers, scale drawings, and not-to-scale diagrams, as well as algebraic models.

Starting Points for Teachers

- Balance instructional strategies to attend to all learning styles – and ensure that the teacher's own preferred learning style does not dominate instruction.
- Discuss learning styles and multiple intelligences with students.
- Use information from diagnostic and formative assessments to determine students' readiness levels, interests, and learning styles.
- Select an important mathematical idea; identify various ways of approaching the idea; pull together the tools that students need to engage in the various approaches (e.g., technologies and manipulatives); organize students in groups to work on different approaches (the action part of the lesson); have students share their strategies (consolidation).
- Create assessment tasks that allow students to demonstrate what they know and can do in different ways.
- When some students have not learned something important, re-teach it using a different strategy while other students work on extensions.
- Clearly identify the learning goals for each group of students when they are working on different activities.

"If I teach and you don't learn, what do I do differently?"

(Anonymous Teacher)

"Howard Gardner's theory of multiple intelligences has provided the educational community with a language that speaks to the strengths and inner gifts of all children, not only those who happen to learn in either the linguistic or logical-mathematical mode."

(Ronis, 1999, p. 43)

Delivering Targeted Support

Providing Enough Time for Students to Learn

Not all students learn in the same way. Moreover, not all students learn in the same length of time. Teachers should focus on the key concepts in a course and allow enough time for all students to learn the big ideas.

Even with the latest teaching methods, some students may still need additional time and opportunities to develop understanding outside regular classroom hours. Targeted, engaging support should be provided to help these students learn and practise in a purposeful manner.

How does this close the gap for at-risk students?

Providing enough time allows all students the opportunity to learn. Additional support that includes meaningful practice built on understanding can help meet individual needs. Prompt feedback as students practise enhances their performance.

Starting Points for Teachers

- Provide a minimum of one hour per day of focused mathematics instruction in Grades 7 and 8.
- Institute a special program (in class or outside of class) that provides additional assistance for students who are struggling in mathematics – for example, tutoring.
- Provide engaging supports that will encourage understanding – for example, games.
- Early in the course, use all available information to identify students who are potentially at risk (e.g., obtain a list of such students from the teachers of previous courses; use board-generated tracking data on students at risk; look at previous report cards).
- Teach with the big ideas of the course in mind.
- Provide students who have misunderstood a concept with opportunities to practise that concept in different tasks over numerous classes so that they come to an appropriate understanding.

In Summary

As teachers implement the instructional and assessment strategies outlined above, they will begin to see changes in their own practice that will lead to improved learning for at-risk students.

Teachers:

Move away from ...	→	Move towards ...
Planning/teaching in isolation	→	Planning/teaching collaboratively with colleagues
Emphasis on cognitive domain	→	Emphasis on cognitive domain plus attention to social, emotional, physical, and reflective domains
Textbook-driven programs	→	Programs based on problem solving
Teacher-centred instruction	→	Student-centred learning – including exploratory/inquiry-based learning
Focus on assessment of learning	→	Balance between assessment *of* learning and *for* learning

Students at risk:

Move away from ...	→	Move towards ...
Focus on completing tasks	→	Focus on completing tasks plus demonstrating conceptual understanding
Participating rarely	→	Participating frequently
Motivation by external consequence	→	Self-motivation
Giving up in the face of failures/ setbacks	→	Setting challenging goals and demonstrating persistence in meeting them
Depending on the teacher for directions, and seeking answers and solutions	→	Using the teacher and classmates as resources, and asking for hints more often than for solutions

Recommendations

The Expert Panel recommends that school boards:

- ensure that all teachers of mathematics and administrators working with students in Grades 7 and 8 and in Grade 9 applied courses – including special education teachers – use the TIPS resource materials;
- focus a minimum of one hour per day on mathematics instruction for all students in Grades 7 and 8;
- provide access to appropriate classroom resources, especially manipulatives, calculators, graphing calculators, and software;
- employ rich, varied, and effective assessment strategies for students at risk in mathematics;
- work with the Ministry of Education and other education partners to develop, where necessary, and deliver research-based intervention programs for students at risk in mathematics.

6 PROFESSIONAL LEARNING

The Expert Panel recognizes that every teacher of mathematics wants to be successful with every student that he or she teaches. Professional learning will equip teachers with the strategies and skills needed to meet the needs of all students – including those at risk.

It is a fact that many educators who currently teach mathematics in Ontario have limited training in the subject content. Each year teachers complete questionnaires in connection with the province-wide Grade 9 mathematics assessment. In 2002–2003, only 32 per cent of teachers reporting on the applied program indicated that mathematics was their major area of study while working toward a bachelor's degree or equivalent (EQAO, 2003c).

"Research on curriculum materials, instructional strategies, school reform efforts, and instructional tools ... all contribute to our understanding of best practices for instruction. Many schools, however, do not provide enough opportunities for teachers to learn how to translate these findings into effective classroom practices."

(Shellard & Moyer, 2002, p.4)

Specialist teachers of mathematics are in short supply. Professional learning is critical if teachers of mathematics in Grades 7–12 are to teach all students effectively and especially to meet the needs of students at risk. In order to build confidence, teaching skills, and depth of curriculum understanding, these teachers must continue in the same teaching assignment for several terms or years. This is especially true for beginning teachers. At present, however, multi-term and multi-year assignments seem the exception rather than the norm.

Teachers of mathematics, whether specialists in the subject or not, require continued support, professional learning opportunities, and focused professional dialogue to improve their practice. The Ministry of Education and school boards must make it a priority to deliver this support to all teachers of mathematics and all administrators responsible for this teaching.

Teachers have much to learn from one another. Teachers can model different approaches and mentor less experienced colleagues. It is advisable for a school to send at least two teachers to professional learning activities, so that upon their return they can observe each other teaching and engage in dialogue about what they have learned and how it can be applied.

Professional learning opportunities for teachers of mathematics who work with students at risk should focus on the following:

- facilitating professional learning communities
- developing a deeper understanding of mathematical content and teaching methodology
- integrating new technologies into the classroom
- embedding the use of manipulatives into instructional practice
- applying current research on the needs of adolescent learners

Professional Learning Communities

The effectiveness of a school depends on the extent to which it develops a professional learning community that enables teachers to continually strengthen their skill and knowledge. Mathematical literacy in general and the needs of at-risk students in particular should rank as priorities for the professional learning community at each school.

Features of professional learning communities with a focus on mathematical literacy may include:

- grade-level, divisional, and cross-panel learning teams to ensure a continuum of skills
- mentorship programs for teachers of mathematics – particularly new teachers
- time for teachers to engage in collaborative activity

Learning teams provide teachers with opportunities to work together to identify challenges, determine possible solutions, discuss classroom strategies, share successes, and identify next steps. Time for collaboration and reflection is necessary if learning teams are to interact effectively. Some activities that learning teams may consider are:

- action research
- professional learning focused on mathematics instruction for students at risk
- group book study
- lesson study
- the sharing of resources and strategies for students at risk
- team-teaching assignments

Teachers in new assignments – both beginning and experienced teachers – need specific professional learning support. This could include team-teaching or opportunities for observation and dialogue with teachers who have undertaken similar assignments.

A Deeper Understanding of Mathematical Content and Teaching Methodology

Research shows that student learning improves when teachers have both a deep knowledge of mathematics content and a sound understanding of strategies for teaching it. (See chapter 4 of this report.)

Teachers with a limited grasp of mathematics content and teaching methodology must deepen their knowledge. This requires a commitment by teachers and the support of their schools and boards. Administrators can support teachers' long-term commitment by:

- actively encouraging teachers to deepen their understanding of mathematical content and of how to teach it;
- creating opportunities for teachers to remain in the same course teaching assignments for several consecutive semesters or years;
- providing time for professional reflection on mathematics, including collaborative learning with colleagues;
- purchasing professional resources to support teacher learning in mathematics;
- encouraging mentoring relationships between teachers with a limited mathematics background and those with a deep understanding of mathematics content.

Integrating New Technologies into the Classroom

Technology can benefit all students, especially those at risk, by reducing the time spent on routine mathematical tasks and by creating opportunities for thinking and concept development.

It is critical for teachers to become adept at integrating information and communication technologies into the classroom. Professional learning activities for this purpose could include:

- ongoing instruction on hardware and software applications and handheld technologies in mathematics
- opportunities to learn how to integrate technology effectively into instructional and assessment plans
- opportunities to raise teacher awareness and competence in the use of assistive and adaptive technologies, with emphasis on accommodations for students with IEPs (e.g., voice-to-text and text-to-voice software)
- regular local workshops to provide updates on learning in the presence of technology
- time for teachers to observe classrooms where technology is an integral part of the learning process

Embedding Manipulatives into Instructional Practice

Students learn by constructing their own understanding of concepts through meaningful investigation and exploration. The use of manipulatives in teaching mathematics is vital to the success of at-risk students in both elementary and secondary school.

The teacher's role is to create connections between the object and the underlying mathematical concepts. Teachers must become confident and knowledgeable about manipulatives as an integral part of their instructional and assessment plan. Of course, appropriate manipulative materials must be available in the classroom.

Professional learning about the use of manipulatives could include:

- planned opportunities for educators to "play" and explore the use of manipulatives in the instructional and assessment processes
- workshops on how to assist students to make the link with mathematical concepts
- visits to classrooms that are using manipulatives successfully
- sessions on the classroom management skills needed to use manipulatives effectively

Research on Adolescent Learners

A substantial body of knowledge has been compiled on the needs of adolescent learners. (See pages 26–29 in chapter 4 of this report for an overview.) Teachers should become familiar with these research findings. To help them do this, schools and boards could:

- provide opportunities for conferences, seminars, or workshops – including sessions on differentiated teaching strategies to meet varying learning styles;
- provide time for teachers to observe the modelling of instructional and assessment strategies and best practices;
- develop a library of professional learning materials such as videos, journals, and websites;
- establish demonstration classrooms.

The Needs of Principals

Principals do not require the same depth of content knowledge as do teachers of mathematics. However, principals must know what sound mathematics instruction looks like if they are to support teachers in this subject. Professional learning for principals should familiarize them with the latest practices in mathematics education. It should also make them aware of alternative assessment methods for at-risk students. This understanding will enable principals to provide sound instructional feedback as they observe teachers' classroom practice.

Recommendations

The Expert Panel recommends that school boards:

- provide sustained, collaborative opportunities for teachers and administrators to meet the needs of students at risk in mathematics through discussion, planning, experimentation, and the sharing of successful practices;
- provide professional learning on the use of manipulatives and information and communication technologies – including assistive and adaptive technologies;
- form a board-wide, cross-panel committee (including both elementary and secondary administrators and teachers) to develop a comprehensive professional learning plan for helping students at risk in mathematics;
- work with the Ministry of Education to develop regional networks of expertise to support the professional learning of teachers of mathematics – including special education teachers;
- work with the ministry to build teachers' capacity in mathematics content and pedagogy, with a focus on students at risk, through regional conferences and other professional learning initiatives.

"Professional learning communities not only build confidence and competence, but they also make teachers and principals realize they can't go the distance alone."

(Fullan, 2003, p. 44)

7 Using Information to Guide Improvement In Learning[1]

The improvement of student learning is only guesswork without information. It is through information that educators can determine what is and is not working in the classroom and at the school and board levels. Information guides the changes that will reduce the gap between high- and low-achieving students while maintaining high standards for all. Information also provides the means to measure results and hold educators accountable for the public funds committed to assisting students at risk.

> "Educators, themselves, ought to be the prime consumers of data in the process of making decisions based on intrinsic reasons for collecting and using data, regardless of the external requirements.... To do this, they must become experts in interpreting data and transforming it into knowledge."
>
> *(Earl & Fullan, 2003, p. 393)*

Information flow is a two-way street. Educators at all levels contribute information to improve achievement, and draw on a rich array of information contributed by others. Information provides a basis for identifying and supporting students at risk, choosing instructional approaches and assessment strategies, and engaging in improvement planning.

Systematic improvement planning is a key to helping students who are struggling with mathematical literacy. Because mathematical literacy develops over time, planning should span grades and help students with the transition to secondary school. School-based planning teams should develop meaningful and attainable goals for the mathematical literacy achievement of all students. Teams representing

1. Portions of this chapter have been excerpted or adapted from the EQAO *Guide to School and Board Improvement Planning* and *Education Quality Indicators Program (EQUIP) – Framework*, both of which will be posted on the EQAO website August 2004.

groups of schools from both elementary and secondary panels should do the same. The planning teams should formulate strategies that will lead to positive improvement over time – particularly for students at risk in Grades 7–12. In fact, schools and boards should move to Kindergarten through Grade 12 improvement planning, because learning in the early grades is the basis for later success.

Various sources of data may be tapped to develop a board or school profile of the students requiring support. In order to give an accurate picture of student success patterns, boards should design data collection processes that follow a population of students, rather than just examining Grade 12 exit patterns by pathway. The earlier the process is implemented, the more progress is likely in improving student achievement.

It should be noted that aggregate data will produce only a general overview of course pathways and student support needs in the district or school. Data collection and tracking on an individual basis will identify specific students at risk and determine whether their needs are being met. A mechanism for tracking the progress of individual students on a long-term basis is an imperative.

The Improvement Planning Cycle

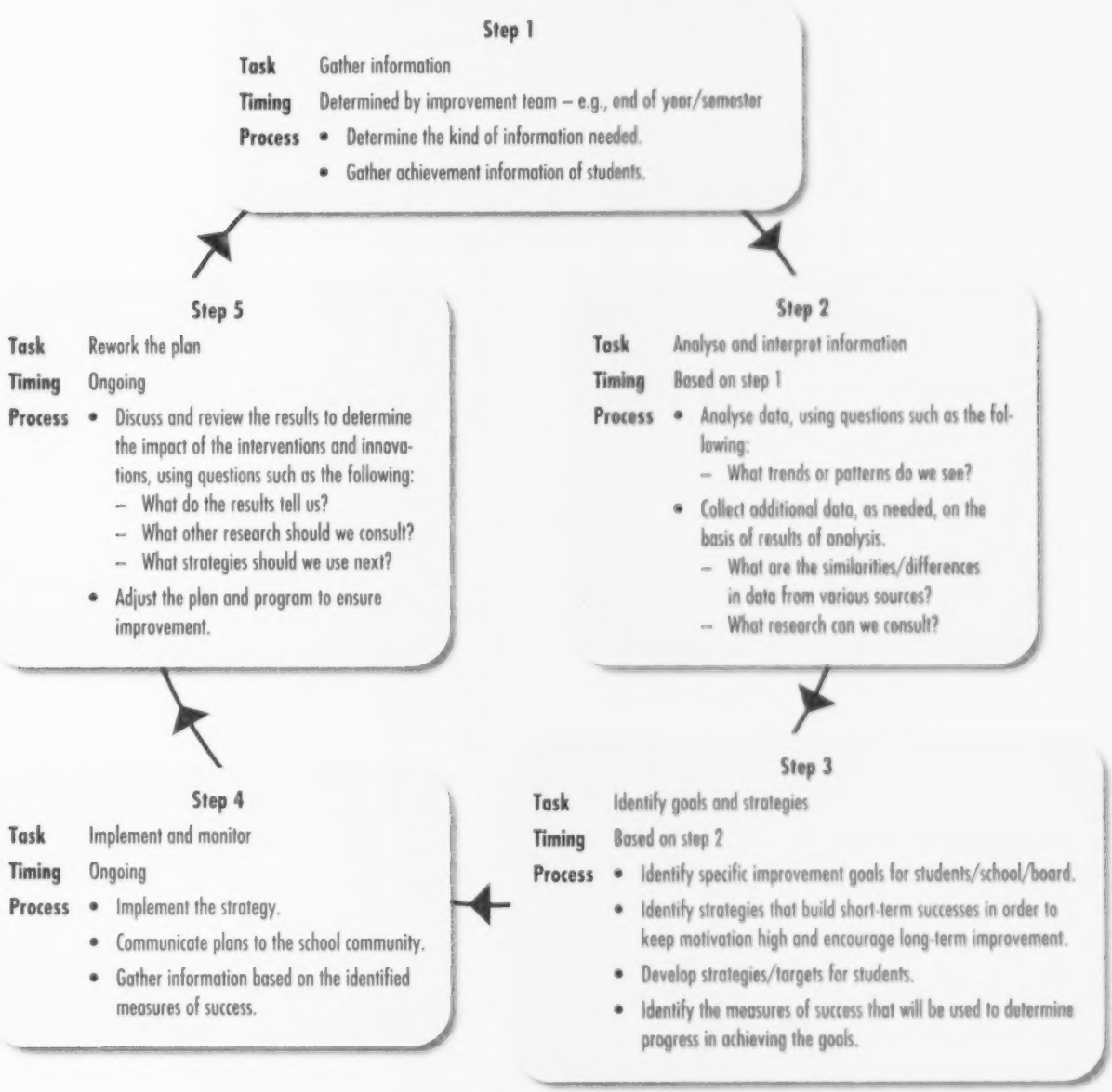
Improvement planning can be done at any level in the education system. The figure on the following page depicts a model planning cycle. It shows how boards with district teams, principals with school teams, and classroom teachers can use information for ongoing planning to improve the mathematical literacy achievement of students at risk.

Step 1: Gather Information

Boards and schools have access to a wide range of information – including report card data, attendance and suspension records, and data on behavioural incidents. At the school level, less-formal information can also feed into the planning process. For example, information on student attitudes, rates of homework completion, and the use of technology and manipulatives can be gathered from teachers, school staff, and parents. The professional judgement of teachers that is based on classroom observations must not be underestimated – teachers know a great deal about their students from first-hand experience.

In addition to school-generated data, boards and schools have access to achievement information from EQAO assessments. In improvement planning, it is important to gather contextual information that supports the understanding and interpretation of EQAO results. The contextual framework is often referred to as the *school and board profile*. The Education Improvement Commission publication *Road Ahead IV* (2000) outlines a profile process for creating this context.

Using Information in the Improvement Planning Cycle


Step 1
Task Gather information
Timing Determined by improvement team – e.g., end of year/semester
Process • Determine the kind of information needed.
• Gather achievement information of students.
Step 2
Task Analyse and interpret information
Timing Based on step 1
Process • Analyse data, using questions such as the following:
– What trends or patterns do we see?
• Collect additional data, as needed, on the basis of results of analysis.
– What are the similarities/differences in data from various sources?
– What research can we consult?
Step 3
Task Identify goals and strategies
Timing Based on step 2
Process • Identify specific improvement goals for students/school/board.
• Identify strategies that build short-term successes in order to keep motivation high and encourage long-term improvement.
• Develop strategies/targets for students.
• Identify the measures of success that will be used to determine progress in achieving the goals.
Step 4
Task Implement and monitor
Timing Ongoing
Process • Implement the strategy.
• Communicate plans to the school community.
• Gather information based on the identified measures of success.
Step 5
Task Rework the plan
Timing Ongoing
Process • Discuss and review the results to determine the impact of the interventions and innovations, using questions such as the following:
– What do the results tell us?
– What other research should we consult?
– What strategies should we use next?
• Adjust the plan and program to ensure improvement.

It is critical to identify students at risk as early as possible in order to intervene effectively. Some students at risk may be identified through EQAO Grade 3 and 6 mathematics scores and school-based data. However, some students may not appear at risk until their first year of secondary school. The transition between elementary and secondary school is often difficult. Careful monitoring of students in Grade 9 is vital for identifying students who experience a disconnect between their elementary and secondary experience.

Examples of sources of information are given in the subsections that follow:

Credit Accumulation

Research indicates that if students do not acquire enough credits in the first two years of high school, their chances of completing enough credits to graduate decrease. Student information systems should be able to provide school and district figures for students earning fewer than 7 credits at the end of Grade 9 and fewer than 15 credits at the end of Grade 10. This information will help to determine the number of students who are not achieving success in the existing program options.

Problem Attendance Reports

The planning team can collect data to establish a normal daily attendance pattern in each school and, collectively, in schools across the district. Once this norm is established, problem attendance reports can then be used to determine students who may be at risk.

Recent studies have indicated that students who have an absentee rate of 11–18 per cent (absent 2.2–3.6 days/month) are moderately at risk and students with a rate of 19 per cent or higher (absent 3.8 days/month or more) are highly at risk. This absentee rate should be correlated with the availability of programs and supports in the school or the board. (See the Toronto District School Board website, www.tdsb.on.ca – Student Success Indicators.)

EQAO Assessment Results

The EQAO produces reports on the province-wide mathematics assessments. This information can be used to determine the percentage of students in the school district, in each family of schools, and in each school who are performing at a level considered at risk (that is, at level 1 or below).

As of the 2002–2003 school year, each student in a publicly funded elementary and secondary school has been assigned an Ontario Education Number (OEN). EQAO will use this identifier on assessment materials to facilitate the tracking of provincial assessment results on an individual basis. This will make the EQAO data more meaningful and useful to schools, teachers, students, and parents.

Apart from the EQAO tests, assessment procedures at both the board and school level can also provide valuable information on student performance in mathematics.

Participation in Intervention or Support Programs

Another indication of the number of students at risk is the number of students who are enrolled in intervention programs or are using supports such as tutoring, resource programs, and targeted remediation.

Administrative Intervention/Suspension/Expulsion Statistics

Students who are disengaged at school often require administrative intervention for attendance, behavioural, or disciplinary issues. Together with suspension and expulsion data, this information can help determine the percentage of students highly at risk in a school or district.

Literacy Test Results

Students who have not been successful on the Grade 10 province-wide literacy test, through failing one or both components or being deferred, are at risk of not graduating.[2] Since mathematical literacy is based on the ability to read and understand, these students are also at risk of leaving school without developing mathematical literacy.

Applied Course Success Rates

Where a school does not provide Grade 9 or 10 locally developed mathematics courses, students who may have taken this option often enrol in applied courses. The number of students who are not succeeding in applied courses indicates the number of students who may be at risk in the absence of other alternatives.

Enrolment in Locally Developed Mathematics, Science, or English Courses

The number of students enrolled in locally developed courses (in mathematics, science, and English in both Grades 9 and 10) and student achievement in these courses should be tracked and monitored to assist with programming decisions.

Registration in Alternative Programs

A school or a board may provide alternative options (Transitions Programs, Supervised Alternative Learning for Excused Pupils, Independent Learning Courses, Youth Access, and Alternative to Home Suspensions). If so, information on the type of program and registration totals can be useful in defining a population of students whose needs are not being met with standard programming and pathway options.

Interviews

Anecdotal information from interviews with all stakeholders can be helpful in determining the needs of specific schools.

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2. Since the introduction of the Ontario Secondary School Literacy Course, more students are developing the skills necessary to earn the literacy graduation requirement.

Correlation of Postsecondary Destinations and Availability of Workplace Preparation Courses

A review of the destinations of students after they leave secondary school will produce a profile of the types of programs that are most beneficial for student preparation. Local labour market needs may confirm this profile. The program profile should be checked against the program availability in the school and across the school board.

Step 2: Analyse and Interpret Information

Once the data have been compiled, the planning team could use a series of questions to analyse and interpret the information. For example:

- Is there anything in the data that the team does not understand? If so, what should be clarified?
- What patterns are evident in the school's or board's data? For example, are the board's data for certain indicators or factors particularly high or low relative to the provincial data?
- What is the relationship between the class-based report card and the EQAO data? Are they similar or different?
- How do the current data compare with the data for the previous years? Do there appear to be any trends in the data?
- How do current data relate to previous results for the same cohort of students?
- Is there anything about the information that is surprising? If there are inconsistencies in the data, how can they be explained?
- Are the students doing as well as expected?
- Considering the relationship between each of the indicators or factors and student achievement, are there any concerns? What does the literature say about the relationship between this indicator/factor and student achievement?
- How closely do the data match the other school-based or board profile data on hand?
- Do any of the data point to a need to review or re-evaluate decisions, policies, or procedures?
- On the basis of all of the data, which two or three elements of the full profile should be considered most carefully in developing the school/board plan?
- In what areas are the results the same, and in what areas have there been changes?
- In what areas has improvement been noted?
- In what areas have the results declined?
- What are the possible causes of the changes – both improvements and declines?

Once the planning team understands the current information and the trends in achievement data, it can begin to determine strengths and weaknesses.

Putting Information in Context

At this stage, the planning team is ready to probe the relationship between the contextual information and the achievement data. Assessment results can be linked to contextual information in the school and board profile and contextual information from such sources as feedback from board staff, principals, teachers, school councils, parents, and students; the EQAO student and teacher questionnaires; national and international assessments; board assessments; local research initiatives; and Statistics Canada data. Asking questions will support this process. For example:

- How do the board's or school's profile data and other contextual information relate to its EQAO assessment results? How might the assessment results have been influenced by specific contextual factors, including board policies, improvement plans, program emphases, staff development programs, and resource and personnel allocations?
- How do strengths and weaknesses in the assessment results relate to the various contextual factors identified above?
- What does the literature say about the relationships noted?
- What are the implications for decision making and planning at the board and school levels and for teacher and parent practices?

Step 3: Identify Goals and Strategies

Once the information has been analysed, the planning team determines the goals and strategies that will focus improvement efforts. The planning team should consider the following three areas:

- curriculum delivery
- school environment
- parental/community involvement

An improvement plan should specify:

- strategies to achieve the goals
- indicators of success
- timelines
- resources required
- responsibilities

Improvement Strategies

Strategies for improvement must be specific and focused. They should take the form of actions that will occur in the school or at the district level that will make a substantial difference to student achievement. The planning team may also want to consider whether a boardwide strategy is needed, perhaps to achieve consistent support across the system.

Some of the questions a team might ask in developing strategies include the following:

- What specific actions would improve student achievement in this area?
- What does current research about instruction say?
- What specific teaching strategies would improve student achievement?
- What specific professional learning is needed to assist teachers in the curriculum area?
- What specific teaching strategies have proved successful?
- What needs to be done differently in the classroom or at the system level in order to improve student achievement?
- What strategies will move students currently achieving at level 2 to the provincial standard of level 3? from level 1 to level 2? or from exempt to level 1?
- What strategies have proved particularly successful with similar students?

Success Indicators

Indicators of success should be measurable, observable, and performance-based. To help determine measures of success, a planning team might ask:

- How will the team know that the goal has been achieved?
- What will be different for students? What will be different for teachers? What influence should the plan have? What data support this notion?
- What evidence must be gathered to determine success in meeting the goal?

Step 4: Implement and Monitor

The team should collect information to monitor the implementation of the plan and the impact on student achievement. The following should be considered:

- Are teachers implementing new methods of instruction and assessment?
- Are new resources or learning materials being used?
- Does assessment information indicate that students are progressing?
- Has professional learning been adequate?

Monitoring will indicate whether each strategy has been implemented on schedule. It is advisable to build frequent points into the time frame for gathering feedback and identifying shortcomings. On the basis of this information, strategies can be maintained, adjusted, or discontinued. By indicating whether or not strategies are working, monitoring supports accountability for the investment of provincial funds allocated to assisting students at risk.

Finally, monitoring creates opportunities to renew the focus on the goals for improvement, and to identify and celebrate successes.

Step 5: Rework the Plan

Staff, school councils, and parents should have the opportunity to examine the information that has been gathered throughout the year and to discuss the effectiveness of the strategies implemented through the plan.

The school and board should examine the indicators of success and determine whether the strategies have made a difference to student achievement. If a given strategy has made no difference, it is important to ask why.

The following questions should be asked in evaluating the plan:

- What further strategies should be introduced to help reach the goal?
- What strategies should be stopped?
- What strategies should continue?

Evaluating progress and adjusting strategies should be viewed as fine-tuning. Changes to the plan should involve revisions to the strategies rather than a rewriting of goals. A school or board plan is a working document, and it is usual to adjust strategies along the way until the desired results have been achieved.

Making the Most of Information

Not all schools and boards have access to the expertise that will make the improvement planning cycle work. Teachers, principals, Student Success Leaders, and other board staff require training in data interpretation and strategic planning to make sense of the information before them and put it to use. Training to support principals in school improvement could include interpreting data, reporting on assessment results, developing the school plan, and communicating the plan to parents and the public. Training to support teachers might include how to identify students at risk and how to use various types of data to plan strategies appropriate for individual students.

The Expert Panel is aware that many educators are finding it difficult to obtain the full information needed to identify and track students at risk. For example, in some districts credit accumulation data are compiled at the board level but are not accessible to schools. As well, major provincial databases have problems with interconnection and compatibility. Because these student information systems cannot readily "talk" to each other, combining data from different sources is difficult. The OEN will help, but it is only one element in the effort to identify students at risk and track their progress in a systematic way. The process for collecting, integrating, and reporting student data is a province-wide challenge that calls for leadership and action by the Ministry of Education.

A Sample Research Project

The following describes a project undertaken by the research department of a school board.

Research Question: Are there any indicators in Grade 6 that could be used to predict success or failure in the Grade 10 Ontario Secondary School Literacy Test (OSSLT) and Grade 9 and 10 mathematics courses?

The researchers selected the cohort of students who participated in the 2002 OSSLT and tracked them from Grade 6 to Grade 10. A database was created that included the following information for individual students:

- report card marks in mathematics, Grades 6–10
- report card marks in language arts/English, Grades 6–10
- number of absences per year
- number of suspensions per year
- EQAO results for Grades 3, 6, 9 mathematics
- EQAO results for Grades 3, 6 reading and writing
- OSSLT results

A series of graphs were created to show:

- performance on the OSSLT in reading versus each of the other indicators, Grades 6–10
- performance on the OSSLT in writing versus each of the other indicators, Grades 6–10
- achievement in Grade 9 mathematics versus each of the other indicators, Grades 6–10
- achievement in Grade 10 mathematics versus each of the other indicators, Grades 6–10

Possible next steps:

- Use the graphs to identify strong correlations in the data.
- Identify goals and strategies for the improvement plan on the basis of these correlations.

RECOMMENDATIONS

The Expert Panel recommends that school boards:

- design and share a mechanism that schools can use to track students who are at risk in mathematics in Grades 7–12.
- develop capacity in information collection and analysis by:
  - providing ongoing training and training materials for administrators and teachers in the use of different types of information to guide instruction, plan strategies for school improvement, and support individual students at risk;

  - working with other boards to organize a province-wide conference to share information practices;

- ensure that schools regularly collect and analyse individual students' information to identify students at risk in mathematics, determine their learning needs, guide instruction, and provide timely intervention;
- ensure that schools identify and track students in Grades 7–12 who show indications of being at risk in mathematics, in order to provide support as students make the transition from grade to grade – with special attention to students moving from elementary to secondary school;
- collect and analyse student data on a regular basis at the district level for the purpose of identifying strengths and weaknesses, measuring success in achieving district goals, and setting future priorities.

"The challenge for leaders is to use data, not as a surveillance activity but in the service of improvement. . . . (T)he essence of accountability is looking forward, using data to inform judgments about current performance and formulate plans for reasonable actions."

(Earl & Katz, 2003, as cited in Earl & Fullan, 2003, p. 393)

8 Leadership: Roles and Responsibilities

The reality of students' lives is that students have more need than ever before to develop mathematical literacy if they are to succeed in the modern world. It is the responsibility of all educators to model and promote attitudes that proclaim the importance of mathematical literacy for all students and to make achieving this a concrete goal for all schools. All educators can and should be leaders in the drive for mathematical literacy for all.

Leadership to promote mathematical literacy for all learners is a collective effort involving the Ministry of Education, boards of education, schools, teachers, and universities.

"(L)eadership, if it is to be effective, has to (1) have an explicit 'making-a-difference' sense of purpose, (2) use strategies that mobilize many people to tackle tough problems, (3) be held accountable by measured and debatable indicators of success, and (4) be ultimately assessed by the extent to which it awakens people's intrinsic commitment, which is none other than the mobilizing of everyone's sense of moral purpose."

(Fullan, 2001, pp. 20–21)

Role of the Ministry of Education

The Ministry of Education has expressed a vision for education in the province: "Ontario's schools should offer an education program that promotes a high standard of achievement, that provides all students with the learning opportunities and support they need, and that is relevant to society's needs and expectations" (Ontario Ministry of Education and Training, 1996b).

To further this vision, the ministry supports strategies for students at risk by:

- setting goals for the education system
- establishing policy and frameworks
- setting standards for data collection and sharing

- ensuring equitable access to curriculum specialists and program leaders
- providing appropriate resources
- setting goals around teacher training and professional learning

Role of School Boards

Board administrators are key to creating professional learning communities that foster improved student learning. Through their beliefs and actions, administrators demonstrate the values of the system and support teachers' work with students. To be effective leaders, board administrators must be agents of hope and carry the conviction that even the most difficult problems can be tackled productively (Fullan, 2001).

Role of the Director

The director of education builds a framework that allows all partners in education to share responsibility for student learning.

Leadership

Directors:

- establish a system-wide vision and commitment to promote mathematical literacy for all students;
- encourage the use of effective assessment and instructional strategies;
- support innovative programs for students at risk;
- celebrate and share success.

Planning

Directors:

- put into place policies, procedures, programs, resources, and staff to support the development of mathematical literacy;
- ensure the alignment of policies and practices at the provincial, board, school, and classroom levels;
- establish a budget that reflects district priorities.

Professional Learning Communities

Directors:

- ensure professional learning for principals to foster professional learning communities.

Role of the Superintendent

Superintendents are responsible for the implementation of ministry and board policies. This role includes support for principals in developing school improvement plans with a focus on improving the mathematical achievement of all students, including students as risk.

Leadership

Superintendents:

- model and promote positive attitudes and enthusiasm for the development of mathematical literacy for all learners;
- celebrate and share success.

Planning

Superintendents:

- develop a strategic plan that focuses on support for students at risk in mathematics;
- develop recruitment and staffing policies that reflect district needs for qualified teachers of mathematics;
- use information to drive instructional decisions, professional development, and the monitoring of progress;
- establish a district process for tracking students at risk from elementary to secondary school.

Instructional Resources

Superintendents:

- ensure that schools have equitable access to technology, manipulatives, and print resources that support an engaging and problem-solving approach to mathematics – especially in applied and locally developed courses;
- ensure that teachers have the capacity to integrate these resources into instruction;
- provide necessary supports to ensure that technology is reliable;
- provide resources to support district- and school-based learning teams focused on improving mathematics instruction for at-risk students;
- review assessment and evaluation policies to ensure consistency in Grades 7–10.

Professional Learning Communities

Superintendents:

- allocate resources to ensure that appropriate professional learning opportunities are available both to teachers of mathematics and to all teachers in the area of mathematical literacy;
- facilitate cross-panel learning opportunities between elementary and secondary school teachers in Grades 7–10;

- provide training and support for principals that will enable them to identify and support exemplary mathematics instruction;
- develop awareness and promote the importance of membership in professional mathematics organizations.

Role of the Student Success Leader

The board Student Success Leader is a team builder who works to strengthen the system's capacity to meet the needs of students at risk. The board leader collaborates with education partners to develop a comprehensive plan that allocates resources to help students at risk achieve their educational goals. The board leader reports directly to the director of education on the district plan for improving achievement for at-risk students and on the progress made.

Leadership and Planning

Board leaders:

- establish a board-wide steering committee to develop a strategic plan focused on improving mathematical literacy for students at risk;
- develop budgets allocating funds to support students at risk in mathematics;
- assist principals to develop school goals and strategies for improving mathematical literacy for at-risk students;
- support action research and innovative projects on strengthening mathematical literacy that focus on students at risk;
- work with district mathematics support personnel to improve mathematical literacy;
- celebrate and share success.

Developing and Sharing Information

Board leaders:

- review existing data to determine successful practices and current needs;
- develop a means of tracking data on at-risk students and a process for sharing information;
- facilitate communication within schools regarding existing supports (e.g., tutoring);
- provide updates and opportunities for input to the Special Education Advisory Committee, school councils, and community partners.

Professional Learning Communities

Board leaders:

- determine professional learning needs and provide appropriate supports;
- promote cross-panel collaboration and professional learning;
- work with provincial, district, and school mathematics experts to determine best practices.

Role of Curriculum Support Staff

Improving student achievement is a team effort that depends on professional learning communities. Schools may have access to curriculum specialists who provide support, encouragement, and professional learning to enhance teachers' work. Some school boards have structures in place that include subject consultants, coordinators, lead teachers, divisional leaders, department heads, and program leaders.

Professional Learning Communities

Curriculum support staff:

- provide professional learning opportunities;
- share their expertise in content and methodology;
- share current research regarding mathematics instruction;
- model effective teaching strategies;
- mentor teachers of mathematics and instil confidence in their instructional abilities;
- participate in school learning teams and action research;
- present or assist with presentations about curriculum implementation.

Planning

Curriculum support staff:

- recommend and share appropriate resources;
- collect and analyse data;
- collaborate with school planning teams;
- monitor the effectiveness of programs;
- share and support ministry directions and provide implementation strategies;
- work with the board Student Success Leader to improve mathematical literacy.

Role of Schools

The role of the school is to enable learning for all. The key to success is school capacity, which includes teachers' knowledge, skills, and dispositions; professional learning; program coherence; technical resources; and principal leadership (Newmann, King, & Youngs, 2000). Working with the board, schools systematically identify students at risk and take action to close learning gaps.

Role of the Principal

Research on effective schools underlines the crucial role of the principal as instructional leader. It is critical for the principal to establish success in mathematics for at-risk students as a priority. Principals must lead the way for schools in addressing the needs of students at risk and must work collaboratively with school staff to build professional learning communities. The principal should identify and develop school leaders and should serve as the "leader of leaders" working towards a common vision of excellence.

Leadership

Principals:

- create and communicate a shared vision that focuses on success in mathematics for all students;
- raise the profile in the school community of the value of mathematics instruction;
- encourage innovations such as:
  - creative timetabling
  - research-based interventions
  - strategies for tracking students at risk
  - strategies for enabling cross-grade, cross-panel meetings among teachers
  - staff mentors for students at risk
  - action research projects to investigate mathematics learning strategies
- promote home/school/ community partnerships;
- celebrate and share success.

Planning

Principals:

- ensure that the school budget reflects and supports the improvement plan for mathematics;
- incorporate research on effective schools into priority setting for the school improvement plan;
- share leadership with staff to move the improvement plan forward;
- support an in-school team model for identifying at-risk students;

- use data to develop, in collaboration with staff, an action plan aimed at supporting students at risk;
- ensure the implementation of student Individual Education Plans (IEPs).

Professional Learning Community

Principals:

- establish a school culture that promotes a professional learning community focusing on mathematics.

Instructional Strategies and Resources

Principals:

- ensure teachers' access to a range of authentic assessment and evaluation strategies that address varying learning styles;
- ensure that the concepts, strategies, and approaches in TIPS are used as a basis for delivering programs by focusing professional learning on this resource;
- conduct regular walk-through visits to mathematics classrooms to build a base of observations for professional dialogue with staff (See Consortium of Ontario School Boards, 2003, TIPS Section 6, "Administrator's Package" for classroom look-fors);
- spend time in mathematics classrooms observing teachers and coaching them in the teaching of adolescents;
- ensure that technology, manipulatives, and print resources that support an engaging and problem-solving approach are available for mathematics classes – especially in applied and locally developed courses;
- facilitate cross-curricular connections in mathematical literacy where appropriate;
- ensure that sufficient time is scheduled consistently in all grades for mathematics – including a minimum of one hour per day of focused mathematics instruction in Grades 7 and 8.

Role of the Teacher

The role of the teacher is paramount in improving student achievement. Teachers are responsible for using a range of instructional strategies that are based on sound learning theory to help all students develop their interests and abilities to the fullest extent.

Teachers work in partnership with other educators, parents, and the community to meet the needs of students at risk.

Leadership

Teachers of mathematics:

- articulate their belief that all students can succeed;
- use their skills, knowledge, and experience to engage in shared leadership;
- celebrate and share success.

Planning

Teachers of mathematics:

- participate actively in the development of school and district improvement plans;
- collaborate with colleagues on strategies that support the development of mathematical literacy for students at risk;
- take part in team meetings to monitor student progress and plan for modifications and/or accommodations;
- plan and organize programs to meet the needs of students at risk;
- plan for effective assessment and evaluation;
- develop and implement IEPs;
- work closely with parents to improve student achievement.

Instructional Strategies

Teachers of mathematics:

- use student data to inform instruction in order to improve student achievement;
- provide a minimum of one hour per day of focused mathematics instruction in Grades 7 and 8;
- use the concepts, strategies, and approaches in TIPS for the delivery of mathematics in Grade 7, Grade 8, and Grade 9 applied;
- provide different kinds of instruction to address the range of learning styles (or multiple intelligences) among their students;
- integrate technology and manipulatives into instruction to aid in student understanding of mathematics concepts;
- use flexible groupings to meet the learning needs of students.

Professional Learning Communities

Teachers of mathematics:

- participate in professional learning programs;
- provide support and guidance for teachers new to the role;
- engage in professional dialogue and share resources that promote best practices.

Role of Universities

Teachers of mathematics in Grades 7, 8, and 9 must have a thorough conceptual understanding of the subject. This understanding goes beyond what is acquired by completing Grade 12 mathematics.

Ontario's approach to teacher education places responsibility for the mathematics education of future teachers primarily on university departments of mathematics. The faculties of education are responsible for selecting and preparing future teachers who have the potential to teach mathematics to all students, including students at risk.

It is time for a comprehensive review of the minimum mathematics requirements for a junior-intermediate teaching certificate. Faculties of education should provide leadership by prescribing minimum requirements that respond to the needs of today's students, including those at risk. The faculties of education and mathematics departments of all Ontario universities should then collaborate to develop strategies for ensuring that these minimum requirements are met.

The faculties of education also have a role in providing in-service professional learning opportunities for all junior-intermediate teachers of mathematics, including those who have little or no undergraduate mathematics preparation.

Recommendations

The Expert Panel recommends that school boards:

- establish a system-wide vision that proclaims the value of mathematical literacy for all and fosters confidence in all students that they can learn mathematics;
- require all school improvement plans to include a focus on mathematical literacy for at-risk students;
- ensure equitable access to programs and resources to support the development of mathematical literacy;
- make mathematical literacy a priority during budget deliberations;
- support continuity in teaching assignments and sustained professional learning for teachers of mathematics – including special education teachers;
- provide professional learning opportunities for school administrators to enable them to support exemplary mathematics instruction;
- align board assessment and evaluation policies to create a seamless transition from elementary to secondary school.

"Leadership is not about official positions of authority. Rather, it is about the school's or district's ability to engage the entire school community in broad-based and skillful participation in learning and improvement."

(Conzemius & O'Neill, 2002, p. 12)

"Our most critical role at the central office is to support learning about learning, especially among principals – who will then do the same among teachers in their schools."

(Senge et al., 2000, p. 431)

9 Family and Community Support

Students learn in many places beyond the classroom. They engage in learning in community recreational and social activities, in sports and clubs, and with their families, friends, peers, and neighbours.

"Brain researchers are finding that resiliency, like intelligence, develops in a nurturing environment."

(Pearce, 1992, p. 83)

Role of the Family

Parents are keenly interested in their children's learning and school success and are often referred to as the "first teachers" of their children. Since children respond to adult expectations, it is important for parents to convey positive attitudes about the importance of learning mathematics.

However, parents' confidence in their ability to help adolescents with mathematics often wavers for a variety of reasons – including a vastly changed curriculum, teaching methods that differ from those they experienced themselves, their own discomfort with mathematics, and the resistance that teenagers can bring to parental involvement. For all these reasons, parents require support in their efforts to help adolescents become mathematically literate.

It is imperative to ease the transition to high school by helping Grade 8 students and parents understand the choices of pathways and mathematics courses available at the secondary level. Each of the pathways should be valued as a first-choice option for some students. A wrong course selection in Grade 9 mathematics can result in failure to earn the first mathematics credit, and such a failure can shake the student's confidence in ways that may be hard to repair.

It is especially important that schools, in communicating with the parents of students at risk, not reinforce stereotypes that some students simply cannot do mathematics.

Teachers should always balance discussion of a student's problems with emphasis on his or her strengths and the plans for improvement. This approach will send a message of hope rather than feeding a sense of defeat.

Role of the Community

A variety of community organizations and resources serve the needs of children and youth. These include Boys' and Girls' Clubs, faith groups, sports and recreational organizations, Scouts/Guides, the Y, and others. Service clubs such as Rotary and Kiwanis may support programs for children and youth by providing funds or volunteers. Municipal and provincial governments assist children and youth through recreational, cultural, and social programs. In addition, thousands of community volunteers work with children and youth through organizations such as Big Brothers, Big Sisters, and others.

Some organizations and programs focus specifically on assisting students to achieve success in school. For example, the Learning Disabilities Association of Ontario and the Association for Community Living advocate for accommodation and support and provide services in conjunction with school boards for students with specific disabilities or exceptionalities. Frontier College provides homework help programs for children and youth in disadvantaged communities. As well, children and youth at risk benefit from peer tutoring programs run by schools themselves, cooperative education placements that bring teacher assistants into schools, provincial Tutors in the Classroom programs, and homework help clubs offered in community venues.

However, there is little coordination among community services for youth in general or students at risk in particular. Increasing the collaboration among schools, parents, and community groups would enhance the effectiveness of these efforts.

Currently, school personnel are not always familiar with the community resources available, and community groups are not always aware of the difficulties facing students in school or how they might help. School boards urgently need to build capacity in community relations and to strengthen community connections to support students at risk.

Role of the School Council

Every publicly funded school in Ontario is required by legislation to have a school council that includes parents as a majority of its members, and includes as well a representative from the community at large. The school council may decide to assist in promoting mathematical literacy by:

- providing input for school planning to support mathematical literacy for all students;

- helping to communicate the school's action plans on mathematical literacy to all families;
- organizing family information sessions, using guest speakers and school staff to increase understanding of mathematical literacy issues;
- supporting the development and sharing of family mathematical literacy resources;
- encouraging parents and family members to attend school council meetings and family information sessions;
- advising the principal on how to reach and support families from diverse backgrounds, cultures, and languages.

Principals, superintendents, and Student Success Leaders all have a part to play in ensuring that school councils have access to current research on mathematical literacy education. This background can help school councils provide input into the school's planning to support students at risk.

Role of the Special Education Advisory Committee

The Education Act and related regulations require that each school board establish a Special Education Advisory Committee (SEAC). The SEAC advises the board on special education programs and services for exceptional students, participates in the board's annual review of its special education plan, and participates in the board's annual budget process as it relates to special education.

SEAC members include representatives from local associations affiliated with provincial or national associations that support the interests of exceptional students and their families. These representatives express the concerns of parents of exceptional students, and can draw upon the resources and expertise of the parent organizations they represent.

Although not required to do so, SEACs often advocate on behalf of at-risk students by advising boards about:

- effective programs and practices related to early identification and early intervention;
- the sharing of effective practices among schools and school boards;
- relevant and timely research;
- board policies, programs, and student assessment practices;
- professional development needs for principals, teachers, teachers' assistants, and other professionals.

Role of Student Volunteers

Senior students can provide valuable support on a volunteer basis for students at risk. They can help out in the classroom – working with small groups, offering one-on-one tutoring, and serving as positive role models. Schools can encourage this activity by ensuring that participating senior students receive credit for community involvement and perhaps by utilizing students enrolled in the Leadership and Peer Support course to tutor students at risk.

Recommendations

The Expert Panel recommends that school boards:

- develop an effective communications plan between home and school to:
  - guide course selection as elementary school students prepare to enter secondary school;
  - familiarize parents with current mathematics instruction and assessment, including hands-on exposure to manipulatives and to information and communication technologies;
  - advise parents on the importance of mathematical literacy and on ways to support students' mathematical learning at home;
- strengthen community outreach to support students at risk in mathematics by providing training and encouragement for community organizations and volunteers.

10 ENCOURAGING INNOVATION

By and large, schools do what works for most students most of the time. While there is room for improvement in mathematics teaching and learning across the board, the majority of students are successful in mathematics under the current system. However, some students are not. Since the role of the school is to enable learning for all, this gap is an invitation for educators to think differently.

"In our economic and social life we expect change, but in the public schools we have clung tenaciously to the ideas and techniques of earlier decades and even previous centuries."

(Gerstner, Semerad, Doyle, & Johnstown, 1994)

Barriers to meeting the needs of students at risk extend from the way teaching and learning are organized and structured to the attitudes and expectations of educators and parents. While it may not be possible to eliminate these barriers, with imagination and courage educators may be able to work around them.

To respond effectively to the needs of students at risk, educators may be forced to challenge conventional thinking about how school is done. Innovation may not be required for the entire student body, so change efforts can focus on the at-risk segment of the student population. Since innovation by definition involves breaking new ground, tested models to guide change may not always be available. Educators must forge ahead to discover what does and does not work, continually monitoring results to ensure that learning by at-risk students is improving.

Educators are encouraged to consider the following ideas as a starting point for innovation.

A More Flexible School Day

The secondary school day is generally structured in a series of 110-hour credits – a unit that may not support students at risk. One strategy that might help is to integrate distance education materials with classroom instruction. Another strategy could be to document the curriculum expectations a student has met in a mathematics course, even while failing it. The student could then earn the credit in summer school or in a remedial program without having to repeat what he or she has already learned.

Under a recent provincial policy change, schools have the option of offering 220-hour, locally developed, single-credit courses in English, mathematics, and science in Grades 9 and 10. The objective is to help students who may benefit from a high school preparation program offering additional instructional time. Schools should make creative use of this new option to respond to the needs of students at risk in mathematics.

Most schools require students to take a disproportionate share of compulsory courses in Grades 9 and 10. For students at risk, it may make sense to defer more of these challenging courses until the later grades.

Under traditional timetables, every class runs for the same length of time. More flexibility could create opportunities for targeted support for at-risk students during the school day.

Instead of offering only courses that centre on one subject, schools may find it worthwhile to use a multidisciplinary approach. For example, a course that combines construction technology, mathematics, and English could be offered. Students could meet expectations in all three areas by constructing an object, performing the mathematical computations involved, and providing a written explanation of the construction process.

Staffing Flexibility

As noted previously in this report, staffing challenges include (1) the need to place in mathematics classes teachers who do not have specialist qualifications and (2) high turnover in teaching assignments.

One innovation could be to cluster a group of students in Grades 7–10 with a group of teachers for at least two years. These teachers would provide instruction, coaching, and other support for the same students during this period. Students would benefit from having teachers get to know them better. Continuity of assignments would also help the teachers build their expertise and confidence in teaching mathematics.

Customized teaching assignments could be considered to meet the needs of small groups of at-risk students. For example, a teaching assignment could start in the middle of one semester and end in the middle of the next semester.

More generally, collective agreements should provide for flexibility in staffing arrangements where such flexibility is needed to support different types of learners.

Overcoming Cultural Barriers

The perception that academic courses are of more value than applied courses has significant repercussions. It leads teachers to prefer assignments to academic sections. It can also influence students and parents in making choices about postsecondary destinations and pathways.

Re-culturing is imperative if the value of all postsecondary destinations – especially the workplace destination – is to be affirmed. Schools and boards have a responsibility to offer the full menu of mathematics courses. Teachers from secondary schools could meet with their counterparts in elementary feeder schools to give them a better understanding of high school pathways and mathematics options. Elementary school teachers would then be in a better position to advise students and parents.

Another cultural barrier is the expectation that some students will inevitably fail mathematics. In an era when mathematical literacy is essential in the workplace and daily life, this assumption can no longer be accepted. Everyone can and must become mathematically literate, and this principle must become firmly embedded in the mind of educators and the public.

> "While advocating ardently for flexibility in achieving the educational aims of schooling, we can still preserve student accountability. No student should be permitted to work, study, or produce less than his or her peers. But we should never insist that everyone put forth identical output. . . . The core theme of K–12 education in this century should be straightforward: high standards with an unwavering commitment to individuality."
>
> *(Levine, 2003, pp. 16, 18)*

Strong, innovative leadership will be required to re-culture our schools. Tools for re-culturing could include community outreach, parent information sessions, the modelling of positive attitudes by teachers and principals, and celebrations of the successes of students from all pathways.

Equitable Resource Allocation

Students at risk deserve an equitable share of a school's staffing and other resources. Educators could begin innovation simply by asking whether the percentage of school resources devoted to at-risk students equals the percentage of struggling students in the total student population. The answer may provide a stimulus for change.

Innovation in Professional Learning

If student achievement is to improve, teachers must increase not only their expertise in pedagogy but also their mathematics content knowledge. In the past, professional development has focused on techniques rather than concepts, so an innovative approach is necessary.

It will also take creativity to find time for sustained professional learning and dialogue. As the RAND Mathematics Study Panel (2003) has observed, the challenge is

> to create arrangements for professional work that supports continued improvement of teachers' knowledge and their pedagogical skills. Meeting this challenge will involve experimenting with ways of organizing schools and school days to support these professional learning opportunities (e.g., scheduling of the week's classes, scheduling for collaborative planning and critiquing, freeing up time for mentoring, or providing on-demand professional development). (p. xvii)

Professional learning concepts that have proved successful deserve broader application. For example, in one innovative Ontario program a gifted teacher leads a summer session in which students explore the mathematics of games – and other teachers help in class and learn new ways to facilitate student learning.

Gap-Closing Programs

In some cases it may not be possible to close learning gaps in the classroom or through targeted support during the school day. Schools should consider further intervention based on successful models – such as a before- or after-school program in which students engage in explorations through manipulatives and learning through games, or a summer camp that imparts a positive can-do attitude by developing mathematical and learning skills.

New Partnerships

Schools and boards are developing partnerships with community colleges to improve pathways for a broad range of students, including those at risk. This trend towards cooperation in developing and offering programs, sharing facilities, and providing professional learning opportunities for teachers is to be encouraged. It could help reap the maximum returns from the public dollars invested in both sectors.

Curriculum Issues

The Expert Panel has found that many teachers of Grade 9 and 10 applied courses in mathematics share significant concerns about the curriculum. They feel that the curriculum is too crowded and does not allow enough time for review, in-depth investigation, group work, and hands-on activities. They also question the progression of content. Several concepts covered in Grades 11 and 12 would be of interest to younger students, and Grade 9 and 10 students could handle these topics more readily than some of the themes that they are now required to cover.

Teachers also report that most students who take Grade 9 and 10 applied courses in mathematics are on a pathway that will lead to work after high school, but these courses may not be practical or relevant to their needs. The Grade 9 applied course is very similar to the Grade 9 academic course in mathematics (more than 80 per cent of the expectations are the same), yet students in the applied program have a much different destination in mind.

Innovation in the curriculum will require action by the Ministry of Education, in cooperation with educators. The Expert Panel is hopeful that these issues will be addressed through the Sustaining Quality Curriculum review process now under way.

Recommendations

The Expert Panel recommends that school boards:

- work with the Ministry of Education and other education partners to:
  - host a major annual conference for educators on innovation to support students at risk;
  - establish an interactive website for sharing innovative practices and promoting professional dialogue to help students at risk;
  - provide a forum for connecting mathematics education researchers with teachers, administrators, and other practitioners.

11 List of Recommendations

The following list compiles recommendations from previous chapters to guide classroom practice, the use of resources, and the expenditure of funds to meet the needs of students at risk in mathematics. Directed to school boards, the recommendations are designed to ensure that students at risk receive the support they need on their journey towards mathematical literacy.

Closing the Gap: Instructional and Assessment Strategies

The Expert Panel recommends that school boards:

- ensure that all teachers of mathematics and administrators working with students in Grades 7 and 8 and in Grade 9 applied courses – including special education teachers – use the TIPS resource materials;
- focus a minimum of one hour per day on mathematics instruction for all students in Grades 7 and 8;
- provide access to appropriate classroom resources, especially manipulatives, calculators, graphing calculators, and software;
- employ rich, varied, and effective assessment strategies for students at risk in mathematics;
- work with the Ministry of Education and other education partners to develop, where necessary, and deliver research-based intervention programs for students at risk in mathematics.

Professional Learning

The Expert Panel recommends that school boards:

- provide sustained, collaborative opportunities for teachers and administrators to meet the needs of students at risk in mathematics through discussion, planning, experimentation, and the sharing of successful practices;
- provide professional learning on the use of manipulatives and information and communication technologies – including assistive and adaptive technologies;
- form a board-wide, cross-panel committee (including both elementary and secondary administrators and teachers) to develop a comprehensive professional learning plan for helping students at risk in mathematics;
- work with the Ministry of Education to develop regional networks of expertise to support the professional learning of teachers of mathematics – including special education teachers;
- work with the ministry to build teachers' capacity in mathematics content and pedagogy, with a focus on students at risk, through regional conferences and other professional learning initiatives.

Using Information to Guide Improvement in Learning

The Expert Panel recommends that school boards:

- design and share a mechanism that schools can use to track students who are at risk in mathematics in Grades 7–12;
- develop capacity in information collection and analysis by:
  - providing ongoing training and training materials for administrators and teachers in the use of different types of information to guide instruction, plan strategies for school improvement, and support individual students at risk;
  - working with other boards to organize a province-wide conference to share information practices;
- ensure that schools regularly collect and analyse individual students' information to identify students at risk in mathematics, determine their learning needs, guide instruction, and provide timely intervention;
- ensure that schools identify and track students in Grades 7–12 who show indications of being at risk in mathematics, in order to provide support as students make the transition from grade to grade – with special attention to students moving from elementary to secondary school;
- collect and analyse student data on a regular basis at the district level for the purpose of identifying strengths and weaknesses, measuring success in achieving district goals, and setting future priorities.

Leadership: Roles and Responsibilities

The Expert Panel recommends that school boards:

- establish a system-wide vision that proclaims the value of mathematical literacy for all and fosters confidence in all students that they can learn mathematics;
- require all school improvement plans to include a focus on mathematical literacy for at-risk students;
- ensure equitable access to programs and resources to support the development of mathematical literacy;
- make mathematical literacy a priority during budget deliberations;
- support continuity in teaching assignments and sustained professional learning for teachers of mathematics – including special education teachers;
- provide professional learning opportunities for school administrators to enable them to support exemplary mathematics instruction;
- align board assessment and evaluation policies to create a seamless transition from elementary to secondary school.

Family and Community Support

The Expert Panel recommends that school boards:

- develop an effective communications plan between home and school to:
  - guide course selection as elementary school students prepare to enter secondary school;
  - familiarize parents with current mathematics instruction and assessment, including hands-on exposure to manipulatives and to information and communication technologies;
  - advise parents on the importance of mathematical literacy and on ways to support students' mathematical learning at home;
- strengthen community outreach to support students at risk in mathematics by providing training and encouragement for community organizations and volunteers.

Encouraging Innovation

The Expert Panel recommends that school boards:

- work with the Ministry of Education and other education partners to:
  - host a major annual conference for educators on innovation to support students at risk;
  - establish an interactive website for sharing innovative practices and promoting professional dialogue to help students at risk;
  - provide a forum for connecting mathematics education researchers with teachers, administrators, and other practitioners.

12 CONCLUSION

Mathematics is embedded in the way we live and work in the information age. Mathematical literacy is a prerequisite for success in today's world. With mathematical literacy, doors are open and the future is bright.

"Teachers must be agents of change that they did not experience as students."

(Anderson and Piazza, 1996)

As a society, we have a responsibility to ensure that all students not only attend school but also learn. The role of the school is to enable learning for all. Every student has the potential to be competent and confident in mathematics, and this potential must be realized.

The challenge of achieving mathematical literacy for all is a complex one calling for a multi-pronged approach. To achieve this vision, the Expert Panel has established priorities for educators to focus on:

- adopting the best mathematics instructional and assessment strategies for all students, with emphasis on strategies that most benefit students at risk, coupled with targeted support as needed
- building and sustaining professional learning communities
- using information more effectively to identify and track the progress of students at risk in mathematics
- providing stronger leadership at all levels of the education system to promote mathematical literacy for all
- strengthening family and community links to support students at risk in mathematics
- encouraging innovation to address barriers to the success of at-risk students

This report has emphasized instructional and assessment strategies that will benefit all students. For students at risk, the use of these strategies is more than desirable: it is necessary. Applying the latest thinking about the teaching and learning of mathematics will go a long way towards improving mathematical achievement by students at risk. In the long run, these changes will help prevent students from becoming at risk in the first place. But even with the best teaching and resources, some students will continue to need extra support, both inside and outside the classroom, if they are to have the opportunity to succeed.

This report offers practical advice and recommendations for meeting the needs of students who are at risk of leaving school without the mathematical competence and confidence demanded by modern society. We know what has to be done. Now it is up to everyone who cares about the future of Ontario's young people to do it!

"Excellence in mathematics education requires equity – high expectations and strong support for all students."

(NCTM, 2000, p. 12)

APPENDIX: SUGGESTED READING

Teachers and administrators need practical information about mathematical literacy instruction and improvement planning if they are to help students at risk succeed. School and board plans should include a component for providing books and other resources.

The following table lists suggested books and indicates relevant audiences for each. Boards are encouraged to maintain their own up-to-date list of suggested resources.

Title	Audience			
	Teachers	Leaders	Administrators	Parents
Adding It Up: Helping Children Learn Mathematics (executive summary is called *Helping Children Learn Mathematics*) National Research Council, Mathematics Learning Study Committee Jeremy Kilpatrick, Jane Swafford, and Bradford Findell (Editors) National Academy Press, 2001. ISBN 0-309-06995-5		✓	✓	
Administrator's Guide: How to Support and Improve Mathematics Education in Your School Amy Mirva National Council of Teachers of Mathematics, 2003. ISBN 0-87353-552-9		✓	✓	
Beyond Monet: The Artful Science of Instructional Integration Barrie Bennett and Carol Rolheiser Bookation Inc., 2001. ISBN 0-9695388-3-9	✓	✓	✓	

Title	Audience			
	Teachers	Leaders	Administrators	Parents
Book Study and Facilitator's Guide (for Elementary and Middle School Mathematics: Teaching Developmentally) J. Bennett, M. Davis, R. Dawson, C. Featherstone, and D. Jones Pearson Education Canada Inc., 2003. ISBN 0-321-17648-0	✓	✓		
Brain Compatible Mathematics Diane Ronis Skylight Professional Development, 1999. ISBN 1-57517-150-3		✓		
Classroom Instruction That Works Robert J. Marzano, Debra J. Pickering, and Jane E. Pollock Association for Supervision and Curriculum Development, 2001. ISBN 0-87120-504-1	✓	✓		
The Differentiated Classroom Carol Ann Tomlinson Association for Supervision and Curriculum Development, 1999. ISBN 0-87120-342-1	✓	✓		
EdThoughts: What We Know About Mathematics Teaching and Learning John Sutton and Alice Krueger (Editors) McREL (Mid-continent Research for Education and Learning), 2002. ISBN 1-893476-02-2	✓	✓	✓	
Elementary and Middle School Mathematics: Teaching Developmentally (also see Book Study and Facilitator's Guide) John A. Van de Walle Addison Wesley Longman Inc., 2001. ISBN 0-8013-3253-2	✓	✓		
Elementary Mathematics in Canada: Research Summary and Classroom Implications Lynda Colgan Pearson Education Canada Inc., 2003. ISBN 0-321-17-649-9	✓	✓	✓	✓
Helping Children Learn Mathematics (executive summary of *Adding It Up*) Mathematics Learning Study Committee, National Research Council Jeremy Kilpatrick and Jane Swafford (Editors) National Academy Press, 2002. ISBN 0-309-08431-8	✓	✓	✓	✓
Helping Low Achievers Succeed at Mathematics Derek Haylock and Marcel D'Eon Trifolium Books, 1999. ISBN 1-55244-010-9	✓			
How To Differentiate Instruction in Mixed-Ability Classrooms Carol Ann Tomlinson Association for Supervision and Curriculum Development, 2001. ISBN 0-87120-512-2	✓	✓		
Making Math Happen in the Intermediate Years Jason Johnston and Troy Parkhouse Elementary Teachers' Federation of Ontario, 2003.	✓			

Title	Audience			
	Teachers	Leaders	Administrators	Parents
Mathematics Assessment: A Practical Handbook for Grades 6–8 William S. Bush and Steve Leinwand (Editors) National Council of Teachers of Mathematics, 2000. ISBN 0-87353-481-6	✓			
Mathematics Education: A Summary of Research, Theories, and Practice Roz Doctorow Thomson Nelson, 2002. ISBN 0-17-620027-4	✓	✓	✓	✓
Principles and Standards for School Mathematics National Council of Teachers of Mathematics. National Council of Teachers of Mathematics, 2000. ISBN 0-87353-480-8	✓	✓	✓	✓
Teaching Reading in Mathematics Mary Lee Barton and Clare Heidema McREL, 2002. ISBN 1-893476-04-9	✓			
Teaching With Rich Learning Tasks: A Handbook Gary Flewelling with William Higginson The Australian Association of Mathematics Teachers Inc., 2003. ISBN 1-875900-55-1	✓	✓		
The SuperSource: Geometry, Grades 7–8 Alan MacDonell (Editor) ETA/Cuisenaire, 1999. ISBN 1-57452-171-3	✓	✓		
The SuperSource: Number, Grades 7–8 Doris Hirschhorn (Editor) ETA/Cuisenaire, 1999. ISBN 1-57452-174-8	✓	✓		
The SuperSource: Measurement, Grades 7–8 Catherine Anderson and Alan MacDonell (Editors) ETA/Cuisenaire, 1999. ISBN 1-57452-172-1	✓	✓		
The SuperSource: Probability and Statistics, Grades 7–8 Alan MacDonell (Editor) ETA/Cuisenaire, 1999. ISBN 1-57452-175-6	✓	✓		
The SuperSource: Patterns and Functions, Grades 7–8 Alan MacDonell (Editor) ETA/Cuisenaire, 1999. ISBN 1-57452-173-X	✓	✓		
What Principals Need to Know About Teaching Mathematics Elizabeth Shellard and Patricia S. Moyer National Association of Elementary School Principals [NAESP], 2002.	✓	✓	✓	
Worksheets Don't Grow Dendrites: 20 Strategies That Engage the Brain Marcia L. Tate Corwin Press Inc., 2003. ISBN 0-7619-3881-8	✓	✓		

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